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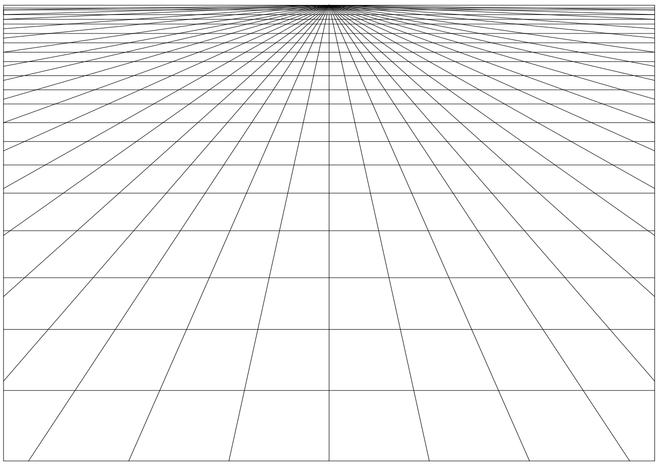

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Demo 2020 – A successful Norwegian joint offshore wind power initiative?

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ABSTRACT

This thesis discusses the joint initiative for creating a test and demonstration park for the development of Norwegian offshore wind power, a working programme coined Demo2020. The project aims to gain necessary experience and lay the premises for Norway to become an international champion providing the best technology available in offshore wind power throughout the whole supply-chain, both institutionally, industrially and through research & development. The initial goal is to make Norwegian technology competitive for a planned large build-up of offshore wind power development around the North Sea.

Through the innovation theory framework Strategic Niche Management (SNM), the thesis examines how the development of the working programme has been developed, and its prospects to win political support on a broad scale. The latter is crucial for the project to reach implementation. However, the findings in the thesis point to major obstacles threatening project implementation. The most obvious is that the petroleum-based industrial regime in Norway is controlled by strong interests both industrially and through the wealth-governing Ministries of Petroleum, Industry and Finance. In a time with demand of climate-friendly solutions, several other industrial initiatives are striving for political favour, thus creating a competition for public necessary attention.

Thus, the Demo2020 initiative needs to be thoroughly managed to gain the necessary political support. Based on a SNM analysis, I have found that the project suffers from weak management, and limited awareness of both the internal and external reverse salients. The thesis discusses thereby relevant policy recommendations and strategies to be pursued for helping immature renewable energy technologies in general, across the so-called "valley of death" and to policy-aided commercialization.

Key words: Norway, offshore wind power, immature technology development, innovation policies, strategic niche management.

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This thesis is dedicated to my good friend Anders, who passed away way too early in life, one month before the completion of this work. Thank you for eagerly following my studies on the sideline and, as a civil engineer, inspiring me to pursue higher (socio-)technical education. Thanks for all good things we experienced together.

Table of Contents

1.0 Introduction

The development of wind energy in Norway started with ambitious plans and visions two decades ago. Recent history has proved that this development path has been challenging. It will not by far meet the ambitious goals outlined to be reached within the end of this decade. For a decentralized industrial growth plan, the development of wind power in Norway has turned out to become no less than a failure. Recent case study research by Thele (2006) and Jakobsen (2008) has described how the joining of local forces has led into strong opposition consensus. This shows clear similarities to the recent political challenges seen in Norway during the summer of 2010 linked to the urgent need of new power grid lines, providing more reliable electrical power supply for the region of Western Norway. These challenges concern the new power of the people, and the strong Norwegian traditions for local engagement on environmental issues that occasionally grows and becomes a national matter, sometimes threatening to put the sitting government at risk. This local democratic tradition is identified to slowly emerge from the 1950ies, when local farmers became heard after the newly built aluminium production plant Årdal Verk caused severe diseases on their local cattle. The aftermath of the learning from this and similar incidents, for instance like creation of hearing processes, shaped *new social democratic institutions* that included *local governance* into the process of infrastructural and industrial development in Norway (Asdal 2007).

This deliberative local governance practice carries out strong influence of the final decision making of industrial development plans throughout Norway. Particularly wind power proposal plans have been met by massive local protests and emerging grass root movements. The legislation and practice of the Norwegian Water Resources and Energy Directorate (NVE) gives local authority proposals high priority when carrying out their final verdicts for wind power concession plans. Fredrik Thele (2006) thoroughly demonstrated how promising plans for a new wind power based electricity regime has been literally decimated through a massive local consolidation of resistance, emphasizing new visions of the understanding of (unspoilt) nature. In his case, concerning the Havsul plans for large scale offshore wind farms on the mid-western Norwegian coast, he shows how these bottom-up movements hook up with special interests, particularly the tourist industry, to shape the consensus that offshore wind power farms in shallow water, as well as onshore farms, are a no-deal in Norway.

The wind power industry in Norway has over the last decade experienced how long-term goals, visions and expectations have fallen on stony ground, politically speaking. The cause of this is relatively clear. As global climate crisis issues have spread to every corner of the world and demanded immediate action, Norwegian authorities have felt that they do not have particular responsibilities in that matter, at least not in the field of renewable energy. After all, Norway fulfils the goals for the EU Directive on renewable energy three-fold. This directive demands 20% renewables of the whole energy production within 2020 in which Norway holds a share of 60% already. Thus, Norwegian authorities are in no hurry of "fulfilling" any goals. However the directive, which also comprises the EEA agreement countries, demands every member state to raise their renewable share of at least 5,5 per cent from the 2005 level. As negotiations are ongoing at the moment, the outcome for the Norwegian commitment is still uncertain.[1] In the meantime, the Norwegian wind power industry has experienced a political and industrial blunder due to the cancellation of the negotiations of a tradable

[1] www.aftenposten.no/okonomi/article3724051.ece

green certificate (TGC) market together with Sweden in 2006 (OED 2009, 102/09). Since Sweden introduced TGCs in 2003, this has fuelled expectations within the Norwegian industry of a better support regime than the one that ENOVA provides today.[2] As the initial negotiation process has been postponed several times, and the ENOVA support system has proved to be a flaw, the industry is facing less and confidence in the economical premises. This provides a particularly unreliable economical climate for industrial actors willing to invest and develop new projects, giving expectations for future support schemes a degree of uncertainty (TU 14/10).

However, this picture is expected to change within few years. TGC negotiations are expected to give the necessary support to land-based wind energy. The government has signalled that also offshore wind will have a future in Norway, although they have neither specified how a given support scheme may create stimuli, nor when this may happen.

1.1 Research design

Objectives – choice of empirical material

"...the development of Norwegian offshore wind power is characterized by a high degree of *technology push,* combined with a lack of *demand pull*"(Benningstad 2009, p. 77). The technology push and the underlying causes for industrial movements that create these have been described by former ESST-master student Lise Benningstad. I will draw further on her findings and investigate a new initiative from the industry itself – an

[2] Enova is the public agency for financial support of renewable energy development.

effort of creating demand by their own visions. Or, more precisely, the effort of the industry to link international demand with new industrial opportunities in Norway, thus establishing a link to overcome the halted situation that has excluded Norwegian actors from the development in wind power seen elsewhere in Europe.[3]

The status quo for the wind power industry in Norway today is that the scale of development of land-based projects is depressingly low compared to the goal set by the authorities in 1999, to have installed 3 TWh of wind power within 2010. Last year the government admitted that this goal will not be met, not even half of it (Teknisk Ukeblad 35/09). Benningstad suggests that the overall goal for Norwegian offshore wind power is to develop both energy-suppliers as well as technology- and competence suppliers. In this thesis, I take a step down from such overall long-term goals, and will investigate mainly what can be achieved within a short time lapse, more specifically *within this decade*. What may make up a significant portion of Norwegian industrial development is more likely, like Benningstad concludes the fostering of technology- and competence suppliers. These can contribute and compete in the (northern) European market of an industry expected to experience massive growth; containing plans to electrify the North Sea. By these means – and the way of achieving this for Norwegian actors – is to start up by building knowledge and know-how through a test and demonstration programme.

The ultimate goal for a demo programme – given the described wind power failure so far - is to provide a strengthened development for wind power technology in

[3] Several countries in Western Europe has provided an aggressive development plan for wind power implementation, which has led to the establishment of a large industry supporting production and deployment of wind turbines. This has led to an international race, a competition for larger and more cost effective turbines, supported by national goals and respective policy schemes (Earthscan 2009).

Norway. The self-acknowledged initiative in response to this is called *"Demo 2020 – the establishment of a test and demonstration program for offshore wind technology in Norway".* This consists of a fully integrated demonstration plant suggesting up to eight bottom-fixed wind turbines, covering complete infrastructure with cables, transmission components and a land connection point, with total costs estimated between 2,5 – 4 billion NOK (Norcowe 2010).

The four core actors that has assembled the project constitutes Norcowe and Nowitech, two public Centres for Environment-friendly Energy Research (CEER), and Arena NOW and Windcluster Mid-Norway, two "Arena"-programmes supported by the Research Counsil Norway (RCN), representing two local industrial clusters respectively. They have invited the authorities to participate to make the financial achievable. However, initiatives from the industry for the fostering of large scale industrial programs have proved to be highly challenging, and this case proves to be no exception. Consequently, the research question is as follows:

To what extent can the Demo 2020 contribute to the Norwegian industrial wind power development, and ultimately increase the supply of wind power based electricity production in Norway?

Theoretical framework

To answer this properly I have applied an innovation theory framework called Strategic *Niche Management.* This is particularly designed for the development of immature sustainable energy technologies – and their ability to diffuse into the prevailing socio-technical regime. To be able to do this, the theory describes certain dimensions of *niche* *formation* that needs to be fulfilled to give a vulnerable technology development the necessary societal momentum. These core dimensions comprise *project design, coupling of expectations, articulation processes* and *network formation* (Kemp, Schot & Hoogma 1998). This forms the starting point where successive activities of experimentations will ultimately lead to higher embedding of this niche into the so-called socio-technical regime.

1.2 Limitations for the thesis

The decision to choose the Demo 2020 initiative as empirical focus for this master thesis became quite clear early in my project. Within wind power development in Norway there is a lot going on the technological side, alongside with network formations and organisational consolidation. Several heavy industrial actors are working in parallel, both in competition and in cooperation with each other. A few demonstration plants have also been proposed, built or lined up in the planning stage[4]. If I had picked a single actor, this would have limited the scope in such a way that the SNM approach would not fit in the same extent, as the combination of R&D institutions and industrial actors gives this project a chance to develop deep network relations reinforcing its ability of niche formation. So when the Demo 2020 initiative was introduced in March 2010 this became exactly the kind of arrangement I was looking for.

The master thesis is conducted in an early stage of the Demo 2020 project proposal. So far, the CEER's, the Arena clusters and the industry have proposed an inviting notification to the ministries of Trade & Industry and Oil & Energy, and are

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[4] Hywind owned by Statoil (former Hydro), and Sway owned by Lyse, Statoil and Statkraft among others, are good examples of technological developments that have reached a certain experience record already.

awaiting a public initiative for further planning, coordination and financial agreements to be undertaken. There are signals that the project concept may be subject to change due to consolidation of actors, and this will be discussed. Several other private and public initiatives alongside with international experiences, would have been interesting to bring in for comparative reasons. However, since the thesis is conducted within a limited amount of time, I have chosen to limit the scope of these influences to only discuss them briefly in the contextual background and analysis section. There is one exception to this, a project called Demo Rogaland which might influence the decision making process. The implications of this project will be discussed thoroughly in the analysis chapter.

1.3 Structure of Contents

The thesis is structured into six chapters that concerns the respective dimensions of the thesis. Chapter 2 accounts for the historical development of wind power and particularly the poor conditions for the development in Norway. It will thereby give the reader an introduction to basic empirical material that constitutes the contextual background for this master project, and sums up the new industrial and political opportunities and developments that has taken place the last decade. Emphasis is given to the *socio-environmental factors* which have been driving this development.

Chapter 3 gives a short introduction to innovation theory and the Strategic Niche Management approach. The first part of the chapter sums up the relevant theoretical developments of innovation theory in general. The second part draws on the early developments of practical application of innovation theory into policy recommendations, which evolves into an elaboration of the SNM framework.

In chapter 4 the methodology in this thesis will be presented. Qualitative data collection and case study design will be discussed with the connection to the relevant theoretical foundation, as well as the aspects of validity and reliability.

In chapter 5 the analysis of collected data will take place, and the relationship between data and theory will be thoroughly discussed and elaborated. The analysis part will first give a broad review of the four core processes concerning the Demo 2020 project as accounted for in SNM theory, and address the implications. Further will the findings from this mapping process be evaluated on the background of SNM theory and the thereby given problems for further discussion. Each section will sum up concluding remarks that will help to answer the research question properly.

Chapter 6 will sum up the main conclusions from the findings in the analysis, and certify that the research question is properly answered. Implications will be summed up, critical remarks to this thesis, and possibly further research.

2. Wind power development – context and background

It is a broad misunderstanding that wind power has become a mature and fully developed technology (Earthscan 2009). It has indeed settled upon several standards, as will be presented in this chapter, but still there are expectations that large achievements are forthcoming, both within incremental as well as radical innovations. The most important ongoing trends within this will be accounted for here. It is however interesting to present a historical overview – particularly given that exogenous events has been driving the development into the design that we know today.

2.1 The early historical development of wind energy

The force of the wind, or movement of air, has been exploited by humans for thousands of years. Archaeological evidences have shown how air valves in excavated houses have been used for natural, hence, passive ventilation. For an active use of wind power converted to mechanical force, traces of vertical-axed windmills have been found in present Afghanistan as early as 700 B.C., for the use of grain-grinding.[5] The innovations that this ancient technology represented, was eventually picked up by European crusaders sacking the area for different reasons, but nonetheless brought back to Europe to fill the same purposes. Moreover, mechanical windmills (this time horizontally axed) got more elaborate societal tasks throughout the centuries to come, particularly for the use of water pumping in the Netherlands since late medieval times.

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[5] Historically, the term *windmill* is used for the device producing mechanical energy, as for the traditional four-bladed medieval-developed technology. Modern three-bladed electricity-producing windmills are usually referred to as *wind turbines.*

The Dutch people drained large areas of shallow seabed and marshland, to reclaim land for agricultural purposes. During the industrial revolution however, the wind energy technology became replaced in favour of coal and steam power as preferred power plants, since these provided better reliability as they were not dependent on steady windy conditions. Moreover, coal and steam power represented greater mobility and could be installed in moving devices such as ships and trains (Ackermann 2005).

It would take a couple of centuries before wind power again found significance, if not for traditional and sentimental reasons, as was the case in rural less developed areas in the western world.[6] Around 1890, as electrification spread throughout the society and created a new socio-technical regime, this *large technological system* had practical limitations that concentrated its development within the proximity of large urban areas (Hughes 1993). For decades to come, the electrical grid technology was not developed neither technologically nor efficient enough to encompass whole continents, as we think about it today. Thus, this created demand for rural small scale electrical power production, and in this matter, wind power eventually became preferable over many alternatives. This was particularly due to its use of an abundant natural resource, while oil or coal fired power plants needs a constant supply of combustibles. Hence, small wind turbines became developed for a market that was neglected by the urban large-scale grid based development (Ackermann 2005).

[6] Traditional windmills still have iconic romanticized connotations, as is the case in the Pigalle area in Paris with its famous red wind mill Moulin Rouge on top of a cabaret club. Likewise, classic (and still working) windmills are scattered throughout the Netherlands (Tansey & Kleiner 2001).

When the World Wars broke out, this brought an extended need for locally produced electricity, as electrical grids as well as centralized power plants became subject to sabotage by enemies. Again, this pushed research and development of wind power to a new level. Particularly initiatives by Danish and American milieus gave significant inputs to the development of large wind turbines as we know them today. However, these prototypes did not become very successful, as material technology was not mature enough to permit installations to cope with the natural forces exposing the vulnerable structures. The practical use of electrical wind turbines in this period therefore became very limited, such as for small scale use in mountain cabins out of range of the electrical grid (ibid.).

2.2 Environmentalism and a new legitimacy for renewable energy development

During the Cold War, the western (as well as eastern) world became subject to major transitions towards societies with a more broadly diffusion of technology. This was fuelled by the competition between the superpowers of the U.S. and the Soviet Union. Particularly the launching of the Sputnik rocket in 1957 created shockwaves into the NATO allied countries. This sparked a major shift in economic activity, since the politicians understood that they had to strengthen the focus of research and development of their hi-tech sector, to cope with what they perceived was a Soviet technological lead. Some fifteen years later, the oil crisis spread new fear of vulnerability because of an over-dependence of petrol-based power production. This led the western countries to initiate large restructuring programs of R&D to exploit new fields of technological opportunities (Wicken 2009).

The oil crisis struck right after an emerging movement of environmentalism had emerged from the late 60ies. During this decade a major attitude shift occurred in the perception of technological breakthroughs that was about to change the society:

> "It is not easy to explain the dramatic shift in attitudes toward technology that occurred in the 1960s. By the end of the decade early enthusiasm for nuclear energy and the space program gave way to technophobic reaction. But it was not so much technology itself as the rising technocracy that provoked public hostility" (Feenberg 1999, p. 4).

The student revolt in Paris in 1968 paved the way for a new generation with a bourgeoisie-rejecting mentality, as they eventually saw through the at-the-time-being purpose of education; to fill institutional posts serving the country with traditional technocratic rule. This movement became concerned about issues like over-exploitation of natural resources, nuclear leftovers, hazardous waste of chemicals and pollutive industrial products (ibid.), which paved the way for completely new environmental policies. In Denmark, this meant that the shortfall of energy could now be overcome by a small scale grass root initiative to develop wind power. The authorities encouraged competition between private (amateur) entrepreneurs to develop smaller and more robust turbines, in which they were inspired by the earlier Gedser turbine developed in the 50ies (Krohn 2002), thus giving the Danes a strong competitive advantage and substantial *know-how* (Lundvall & Johnson 1994).

In the aftermath of the oil crisis several countries like the U.S. and Sweden, sparked R&D programmes for developing commercially viable large scale wind turbines. In this trial-and-error phase we saw various different designs, like vertically axed, and one-, two- and three-bladed horizontally-axed concepts. However, "the technical challenges of building reliable and cost-effective wind turbines on this scale were underestimated and these prototypes did not lead directly to successful commercial products, although much useful information was gained“(Fox 2007, p. 54).

The California Wind Rush and the subsequent Danish wind success

The U.S. state of California they therefore adapted a different approach, creating a support scheme that led to deployment of thousands of small simpler turbines, as a response to the rapidly increasing oil prices. This proved to be a short-led policy trajectory, as this wind programme ended in 1986 (Krohn 2002). However, during the programmes duration of six years, this gave a significant boost to the Danish industry, which by the time held had the national environment with the best R&D environments and accumulated experience, thus gaining a technological lead on wind turbines. The background for this applies to the windy conditions that has always have been a part of daily life in Denmark, where local initiatives of small scale turbine developments have existed since the beginning of the 20th century. It is therefore no surprise that the large scale Gedser turbine developed as early as 1957 with three blades, a diameter of 24 meters and a rating of 0,2 MW, proved durable enough to became the trendsetter for the design that is still dominant today. This so-called “Danish” concept was elaborated further particularly during the Californian rush, to include several important incremental innovations (Krohn 2002, Fagerberg 2005). Among these included stall regulation, fixed speed and blade pitching, which tunes the blades to automatically ensure maximum effect to any given wind speed. By the mid-1990ies the size of wind turbines had grown so much that more advanced tuning- and steering-technology needed to be developed. Here we saw variable-speed operation, gearboxes and advanced light-weight composite materials introduced, forcing the size and effect to the maximum physical limits (ibid.).

2.3 Offshore wind power

As the wind power development in Europe has reached a degree of momentum during the last decades, a natural development further is now growing offshore, due to the EU 202020 target. Even this is not a particularly new trend. The Danes were the pioneers also here, building their first offshore farm in 1991. The ongoing development from onshore turbines continues to push the physical limits forward. The driver of the development today is the race for bigger and bigger units to be deployed offshore in shallow water. Turbines for land use have reached an upper practical limit to how large they may be built, as they must be transported by specially designed trucks driving the components on local windy as well as conventional roads. Hence, the sheer size of land-use turbines is unpractical to develop above 5 megawatt, since this will complicate logistics and significantly increase the cost of road building in- and outside the wind farm (Earthscan 2009).

At sea, however, the physical limits are less restrictive. Turbine components to be deployed offshore may be manufactured at harbour sites, and transported on specialized barges and ships. Cranes on these vessels also have tremendous dimensions, allowing the turbines to be scaled up significantly. The cost of offshore deployment rises exponentially compared to onshore. Therefore, the trend is to strive for bigger units, thus minimizing the number of operations, infrastructure and cable costs, per produced megawatt (ibid.). At the time of writing, the largest successfully tested prototype turbine is the E-126 built by German Enercon, rated 7,5 MW (Enercon 2010). It has fierce competition, however. Among many of these are the Norwegian company Sway which has been granted concession for an onshore test turbine with a rating of 10 MW, to be developed for use in both bottom-fixed and floating configuration (Norwea 2010).

The planned ocean zones for development have also grown tremendously the last years. From the small scale trials in Denmark consisting of a dozen turbines in the first offshore wind farms, the largest farm as of October 2010, Thanet offshore wind farm, has 300 MW installed effect divided on 100 turbines. But this record will not last for long, as national competition drives the respective energy departments to develop bigger and bigger zones for deployment. United Kingdom is nonetheless the leading national offshore actor. 1300 MW has so far been installed here, but this number will within a few years time be scaled up exponentially. This is needed to cover their own set goals for an electricity need of 25% renewables within 2020. In sheer numbers – UK is building and has granted concession for 8800 MW which equals roughly 3300 wind turbines (although this number is highly subject to turbine development) or 26 TWh, one fifth of the entire annual electricity production in Norway. Considerably more is planned for in the UK. The Dogger Bank field alone, in which Statkraft and Statoil are developing partners through the consortium Forewind - has a potential of 9000 MW installed power. This puts a perspective to the industrial possibilities that is expected to arise here.[7] To make this possible, the unit and installation costs must be continuously lowered as the zones being developed are subsequently farther away from shore – thus increasing the infrastructure and logistics costs significantly. All the numbers accounted for here, concerns bottom-fixed turbine deployment, as the development zones in UK are not deeper than 60 metres maximum. This is where the Demo 2020 initiative now presents plans to participate – to get a chance of being part of this. Norwegian stakeholders were more concerned of the future development of floating turbine

[7] http://www.statkraft.no/pressesenter/nyheter/storbritannia-storst-i-verden-pa-havvindkraft.aspx

technology until recently[8], but has eventually realised that there is an enormous market to be exploited of more mature technology before this has fully matured.

2.4 The state of wind power in Norway

The status of wind power development in Norway at present is characterized by the fact that is has been paid little attention too for decades, compared to European traditions. Figure 1 shows the sparsely development in the 90ies, before the picture started to change during previous decade. From the level of 0,9 TWh in 2007, this is expected to rise to 1,6 TWh within the first half of this decade, but still way behind the old target

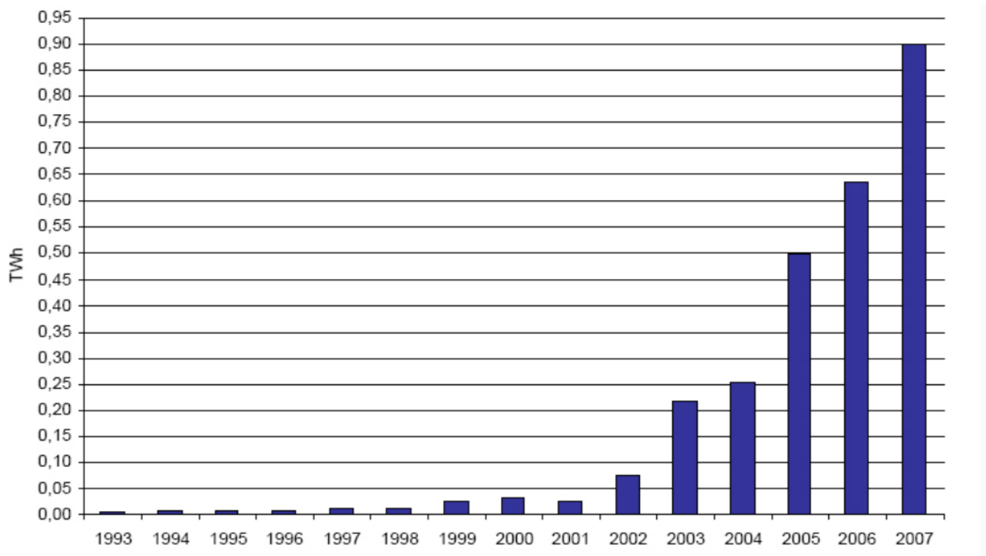

Fig. 1. Production of wind power in Norway 1993-2007 (Source: NVE)

of 3 TWh by 2010, set by the parliament in 1999 (TU 35/09). However, NVE (The Norwegian Water Resources and Energy Directorate) claims that the target can be met,

[8] Not only Norwegian milieus are curious about floating technology, several other nationalities are looking into the future potential here. The most spectacular in that matter is a British concept of a vertically-axed floating turbine, allowing all heavy components to be situated close to the shoreline and thus reducing weight and costs. Source: http://www.engineerlive.com/Power-Engineer/Engines_Turbines/Vertical-axis_wind_turbine_gets_go-ahead/21376

measured by counting all existing wind farms together with project plans, including those with advance notice for concession process. These counts for 1800 MW in total, equivalent of 5,4 TWh. Thus, NVE suggests 45% of announced plans to be scaled down and/or cancelled.[9] However, the numbers counted by the industry tell a different story. For instance, the Havsul projects described by Thele (2006), initially had a total output target of 1885 MW (Havsul I, II, III and IV) (Time 2006), of which only 350 MW, Havsul I has been granted concession.[10] This equals only 18% of the originally proposed plans, initially claiming to be necessary to avoid a power deficit in the mid-western region of Norway (Thele 2006). It would be unfair to say something in general on basis of the Havsul example, but the argument is that NVE has been a bottleneck for project realization, as well as the Enova support regime (Norwea 2010, TU 14/10).

It is thus reasonable to argue that there is a systemic problem with the lack of a master plan, which creates a big challenge to achieve overall targets. It has been indicated that the authorities should guide NVE to look closer at the overall target when working on individual concession plans (Benningstad 2009). However, it should be added that there are a lot of obstacles hindering a majority of the rejected projects to go through, most notably a weak central electricity grid, without present capacity to cope with a desirable amount of newly developed TWh.[11] The national electrical grid developer Statnett is working with major plans for a new super-grid in Norway, but it is expected to years, maybe decades, before this process will become completed (ibid.).

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[9] http://www.nve.no/no/Energistatus-2008/Energiproduksjon/Vindkraft
[10] http://havgul.no/prosjekter.htm
[11] See Thele 2006 for a thorough explanation of the public concession processes for proposed energy plans.

The work done by Thele (2006) and Jakobsen (2008) shows that most proposed wind farm plans proposed in Norway face heavy local opposition. This is usually carried out by grass root movements organized by local lay-people, as well as environmental organizations with interests in for instance ornithological environments. The motive is often linked to the Not In My Back Yard attitude (ibid.). There are a few exceptions, for instance within the municipality of Træna, where electricity shortage is a threat to the community and thus giving legitimacy for a higher consensus of positive attitude towards wind power plans.[12] Jakobsen (2008) has shown how Denmark has followed a completely different tradition in terms of the involvement of locals, thus shaping another consensus, in small-scale wind farm developments. Since the 70ies the Danish people has been involved personally, given the energy crisis fuelled by the oil crisis in '72. Energy shortage concerns in Denmark came alongside with the new environmentalism movement, which translated into practical thinking concerning new solutions. Plans for nuclear power existed in Denmark as well as in Norway and Sweden. Particularly in Denmark, with its small area, concerns about where to store nuclear waste fueled an urgent need for new solutions to emerge. This boosted private initiated small scale wind turbine development, creating a positive legitimacy for deployment. It provided farmers, ordinary townspeople and local stakeholders with revenue income from production, as it is usual to invest in these developments (Krohn 2002, Jakobsen 2008).

[12] http://www.nnvind.no/content/download/1337/10435/file/NVE-%20Vardøya-bakgrunn%20for%20vedtak.pdf

In Norway on the contrary, wind power development has been driven mostly by hydro power and grid companies with a heavy capital base. The conception among lay-people is that wind power development in Norway only will gain these companies when it comes to revenue, and this creates opposition against such plans (Thele 2006).

3.0 Theoretical framework: Strategic Niche Management

3.1 Introduction to innovation research and theory

The Strategic Niche Management approach is one of many research fields that elaborate ideas which originally saw daylight through the disciplines of evolutionary economics and science and technology studies. Before we endeavour on the SNM concept – it is natural to first give a presentation of the development of innovation research and theories. Modern innovation theory usually pays its credits to the evolutionary economy legacy founded by Joseph Schumpeter. Working with this issue around the middle of the 20th century, he argued that

> …it was not sufficient to study the economy through static lenses, focusing on the distribution of given resources across different ends. Economic development, in his view, had to be seen as a process of qualitative change, driven by innovation, taking place in historical time" (Fagerberg 2005, p. 6).

His notion of evolutionary development was inspired by biology, as he argued that innovation occurred through the evolutionary processes of technical change (ibid.). Raven (2005) elaborates this: "In his view, technical change was a process of unfolding, or creating new combinations and he emphasised the evolutionary character of change" (p. 26). Although his work was not very acknowledged by his contemporaries, since the 70ies his tradition has been picked up by scholars and re-interpreted several times over again, challenging neo-classical economical views in the shaping of innovation research (Fagerberg 2005). The research activities have thus branched into many applied innovation theory directions. Subsequently, the elastic term innovation has been given a multitude of definitions, depending of the context. Still the most influential scholars agree on a core definition. Jan Fagerberg's short definition is as following; "the first attempt to carry an idea for a new product or process out into practice" (ibid., p. 4). He emphasizes this important distinction from being mixed with *invention*, which he refers to as "the first occurrence of an idea for a new product or process" (ibid.). The "carry out into practice" notion is important, as many well-meant inventions may never leave the sketching board, notably because it simply may not be practically feasible to develop it, or that that the inventor does not have the know-how of how to do so. It can also be contextual limitations that hinder this. Hence, innovation concerns practical actions that imply a practical change, an improvement of a product or a process. In most circumstances, this innovation has an incremental improvement from its predecessor.

Further, scholars have distinguished these *incremental* innovations from *radical* innovations. These are characterized by their "introduction of a totally new machinery" or "technological revolutions…innovations that together may have a very far-reaching impact" (ibid., p.7). Parts of wind power technology, and particularly offshore wind power technology, can be defined as the latter, radical innovation, since it is being (at least has been) introducing game-changing technologies.

A systemic approach to innovation

Innovation research trajectories have usually been structured into some kind of systemic conceptualization. Thus, *innovation systems* exist in many dimensions. Two scholars, Lundvall and Nelson, have been paid particular respect for their contribution to the shaping of the National Innovation Systems (NIS) framework, developed in the early 90ies. This encompasses innovative activity within national borders, which makes empirical analyses relatively easy to carry out, as the inputs often may be collected from already present statistics. NIS research "has proven to be influential among policy makers in this area, especially in Europe" (ibid., p. 13).

The systemic innovation approach makes it possible to elaborate broader on the definition of innovative activity, and how these activities are characterized by the social processes encompassing and nurturing the occurrence of them:

> ... new research showed that innovation is generally an interactive process in which later steps in the process are linked back to earlier ones. Also, innovations are not usually singular events that result from the genius of individuals. Rather, innovation comes about as a result of the social process involving an interplay between many individuals and organisations over a longer period of time in which cumulative learning processes take place (Lundvall 2002, p. 43).

By scrutinising innovative activities in between the national and organizational level, we find a certain peculiar observation of the localisation of such. Already in 1939, Schumpeter noted that innovation activities often happened within a certain geographical region or proximity, which provided a competitive advantage for growth in the specific region (Fagerberg 2005). This has provided scholars with the puzzle of the formations of what has been given the name *clusters*. These do not necessarily have to be localized within large cities, they may be situated in a (rural) region in which craftsmen have specialized a particular kind of product for centuries, giving the area an accumulative know-how unsurpassed by rivals. This localised cluster may continue to enhance this specialization, thus maintaining its competitive advantage through local "buzz"; tacit knowledge transfer often shared orally among co-workers, and thus difficult to spread as easily outside the region (Bathelt, Maskell & Malmberg 2004). Today however, in modern business, "global pipelines" and codification strategies may facilitate the spread of production, sub-assembly and know-how to alliances in other areas, through air travels and instant information and communication technology (ibid.). Thus, good knowledge management in innovative activities, whether local or global, is highly important to create strong competitive milieus capable of coping with the rapid technological development worldwide.

3.2 The strategic niche management framework

Within the innovation research policy literature, this is one of several interesting and different approaches that may be suitable for applicable analyses of newly developed technologies. The SNM field is developed quite recently, and among scholars there is an ongoing debate of what is the main application for the approach. For this thesis however, Caniëls & Romijn (2008) gives a clear definition of its main contribution:

> Strategic niche management (SNM) is a recently developed approach that could help induce a broad socio-technical transition towards more sustainable development. It is designed to facilitate the introduction and diffusion of new sustainable technologies through protected societal experiments in fields such wind energy, biogas, public transport systems, electric vehicle transport and eco-friendly food production. A major challenge in SNM concerns the processes by which such experiments can evolve into viable market niches and ultimately contribute to a broader shift towards sustainable development (p. 245).

By this definition, we can quickly note that SNM deals with a complicated interrelated contextual material. It is therefore needed to outline some basic ideas of the concept. Before we elaborate further on the details of the framework, a short background for the perceived need for the SNM development will therefore be accounted for to better give a relevant understanding for how to perceive it.

A short background for the SNM development

Innovation theory and research has abounded in a multitude of branches during the last decades. The variations of different theoretical sub-foundations in the innovation policy field – explains how complex social environments appear to have broad and deeply embedded influences on habits and rules-of-the-game for decision-makers. These many policy research milieus have grown out of an experienced need and belief in providing concrete recommendations for policy makers, stakeholders and university-industry linked actors. The need for such new policy recommendations has been clarified by concerns that has grown deeper as innovation scholars has realised that acknowledged policy tools considered adequate by decision makers, seems to gain poorer results for the expected growth of immature and emerging sustainable energy technological developments (see for instance Fagerberg 2009b). This is partly linked to the death of the linear model, a "modernist" legacy from Vannevar Bush and the happy 50'ies – arguing that a steady funding to the university sector is basically sufficient to provide innovation and growth that ultimately will spread throughout the whole society (Mowery & Sampat 2005). Since the 80ies and 90ies when the linear model became heavy criticized, this backdrop opened up a large public, national and international space for trials and errors for different innovation & growth policies. These were based in research milieus on various empirical and theoretical assumptions of more evolutionary based innovation theories, often coined national innovation systems (Lundvall 2002).

However, many of these have proven to have shortcomings for promising new technologies, needing specific policies to cross over the "valley of death". This notion refers to the void not picked up by policy support schemes, in the area between small scale experimentation and full scale commercialisation (Schot & Geels 2008, p. 538). SNM theory has thus developed as a response to these approaches, which often has lingered as to blurry concepts, without adequate possibility to develop into applicable and practical policy tools. One of these approaches is the theory of *Transition Management* by Rotmans, Loorbach and others. Schot & Geels (2008) argues that in many practical applications of this theory, the follow-up of well-meant visions becomes indistinct. These function well in the visioning phase of the experiment, but history has proven that many experiments end up as single-experiments, without adequate follow-up to ensure any regime change:

> In a critical interpretation, one might say that many of these exercises have become rituals, where actors express good intentions as a form of public 'impression management'. While we recognise that reproductions of rituals may sometimes provide conditions for change, there are many instances where they have little real influence. Hence, SNM scholars have stressed the importance of 'hands-on', real-life experiences in demonstration projects; SNM assumes that *actual implementation* and *specification of visions* in experimental settings is most conducive for niche development (Schot & Geels 2008, 542) [my highlights].

Thus, one of the benefits of using the SNM approach for regime changing-purposes is its ability to embed experiments in an ongoing "glocal" experimentation culture (Dicken 2007),[13] which ensures that every new experiment within a certain type of technology adds accumulated knowledge and visions (and thus constitutes niche development), and that this will reinforce the niche formation process.[14] The argument is that an increased structuration of activities in local practices will ensure that the socio-technical regime

[13] Referring to intervening activities pursued on both a global as well as on a local level.
[14] I have chosen to use the term niche formation here (from Kemp et al. 1998), as oppose to niche development. In my view, *formation* describes clearer how the described underlying processes *form* (or shape) the niche.

more easily will re-configure to incorporate new sustainable technologies. This encompasses recent SNM development, which acknowledges that lock-in processes, complicates *regime shifts* as described by early SNM theory, and rather focuses the goals to a *co-evolutionary regime change* (Schot & Geels 2008, Caniëls & Romijn 2008). Rob Raven (2005) elaborates how the dominant regime creates difficulties for the diffusion of niches:

> SNM emerged from the observation that many sustainable technologies fail to succeed. SNM perceives the development of new technologies against the backdrop of a *dominant regime*, i.e. a set of *rules* embedded in a dominant design and social network. To make new technologies flourish, it is necessary to create protected environments [technological *niches*], in which actors can experiment with technologies and rules that deviate from the dominant regime (p. 323) (my highlights) [my addition].

What is important here is the understanding of how these set of regime rules require actors to cope with the perception of the cognitive limitations to what is achievable within the regime. This acknowledgement, of the cognitive boundaries that the regime encompasses, is where SNM sees opportunities in developing the protected spaces for promising technologies.

3.3 Overview of the SNM framework

The goal for SNM is to accommodate for regime change and socio-technical transition. A basic premise for this to occur is that a viable niche is developed. *Niche formation* is therefore a core process to be investigated when an analyzing a technological trajectory through the SNM framework (Kemp et al. 1998). On the basis of the SNM definition in section 3.2 - I would like to add to the last sentence from the quote from Caniels & Romijn – that SNM also deals, at least theoretically, with how new sustainable technologies ultimately *changes* and adapts or transforms the existing regime in the socio-technical landscape, at the macro-level[15] (see for instance Geels & Schot 2007). The notion of *viable market niches* is thus perhaps an understatement – since the niche phase of technological development could be considered temporary.

However, recent research has found that not only extensive niche experimentation is needed before this change may occur. The point of argument is that early SNM theory became criticized for suggesting too heavy that strong niche development would lead into regime shift endogenously. While SNM research provides evidence that there is a correlation between the design of experiments and outcomes in terms of technological and market niche development, it is also clear that internal niche developments are not the only important factor to fulfil this. External factors also play a crucial role. Niche innovations are rarely able to bring about regime transformation without the help of broader forces and processes (Schot & Geels 2008, 545).

The multi-level perspective

A multi-level analysis is therefore needed for exploring the relationship between internal and external processes constituting an eventual niche formation. By taking the exogenous context into consideration, one gets a better view of the all the complex

[15] Definition of the socio-technical regime and landscape will be clarified and elaborated later in this chapter.

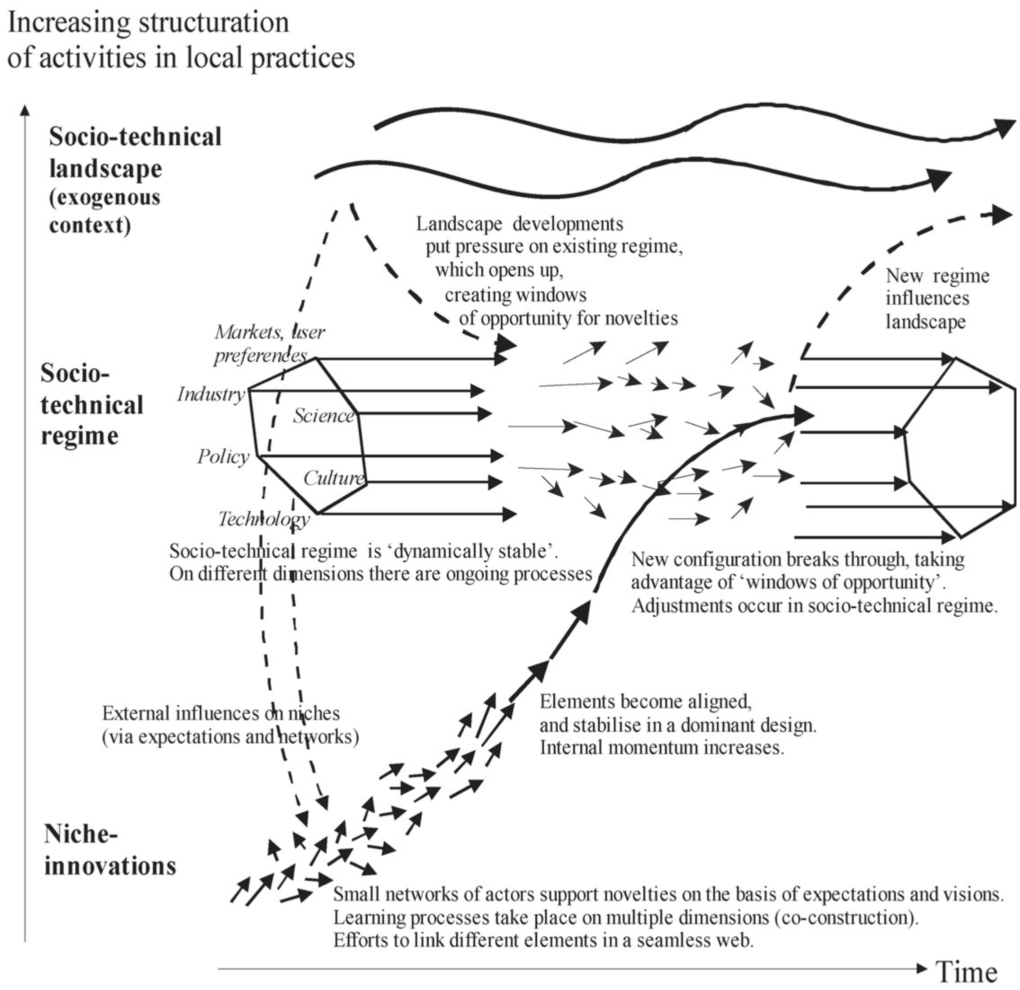

Fig.2. Multi-level perspective on transitions (from Geels & Schot 2007).

factors influencing regime formation. Figure 2 shows how niche innovations (immature technology developments) are facing a tough competitive milieu where only the actors best aligned through necessary networks and strategic alliances have a chance to become embedded into the socio-technical regime. This regime consists of a spectrum of societal dimensions. The most important here is the technological, which Rip and Kemp have given the following definition:

> A technological regime is the grammar or rule-set embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems – all of them embedded in

> institutions and infrastructures. (Rip & Kemp 1998, cited in Raven 2005, p. 27).

Further is the *socio-technical regime* the confluencing of other societal regime dimensions, including science, industry and policy regime, user and market regime, and socio-cultural regime, as illustrated in fig. 2 in the medium level. This regime is characterized by the ruling economic activity (in the Norwegian case the petroleum industry), carefully protected by its stakeholders and alliance partners. On top of this perspective is the *socio-technical landscape* level which is characterised by:

> "the relatively hard material and immaterial context of societies... natural resources, infrastructures (electricity, roads city planning), political cultures and coalitions, lifestyles, macro-economic aspects (oil prices, recessions), demography, and so on are part of this wider context" (Geels & Kemp 2000, cited in Raven 2005, p. 31-32).

Through exogenous activities in the landscape level, such as the Macondo-disaster in the Gulf of Mexico the summer of 2010, this sometimes creates "windows of opportunities" where niche actors may get a chance to get strengthened attention and may have a chance of inclusion into the regime (Schot & Geels 2007, 2008). By increasing the structuration of activities in local practices, the vertical axis in figure 2, these have a better chance of getting appropriate influence, as this increases the level of "buzz" (Bathelt, Malmberg & Maskell 2004).

3.4 The vision of a future regime change

A future technological regime change may seem overwhelming and out of reach for stakeholders of a promising technology. However, the development of new vulnerable technologies is usually surrounded with opportunistic mentality and behaviour, protected by guardians that is coping with the extended risks, technologically and financially, encompassing these "hopeful monstrosities" (Mokyr 1990, cited in Schot &

Geels 2008). An overall goal for the SNM framework is therefore to contribute to regime change, ensuring that the technology in focus will be embedded into this:

> Regimes are characterised by a higher level of stability. Rules are similar and shared among many different locations. They are stabilised and embedded in a system of actors, social networks, technological artefacts and infrastructures. Regimes offer more structuration to local practices, there is a high level of certainty about "which configurations work and which do not" (Raven 2005, p. 46).

Raven argues that early SNM research had shortcomings when it came to the perception of the maturing process and the transition from a niche to a viable market product. "Single experiments do not result in regime changes; they require a long trajectory of many experiments and the emergence and stabilisation of a niche level" (ibid., 45). The experiments in Denmark gaining incremental improvements on wind turbines in the 70ies and the 80ies serves well as an example of the competitive advantage that this localised milieu experienced and accumulated during this period. Raven suggests that recent SNM research is paying better attention to the slowly development of a generic innovation.

As far as the Norwegian offshore wind power case concerns – is an SNM approach also a necessary step to provide new incentives for a more aggressive development of wind power in Norway. This is based on the fact that the development so far has led to a massive industrial failure, due to the underestimation of the importance of analyzing socio-technical factors and the lack of a master plan (Benningstad 2009, Jakobsen 2008, Thele 2006).

3.5 Design of the SNM analysis

The analysis of the Demo 2020 programme takes place on a level where it has reached certain proposed specifications to its outer extent. As I have mentioned in the introduction, measuring the activities constituting niche formation is the analytical approach in this thesis. Kemp et al. (1998) provides a manual with five necessary steps that first must be undertaken for making sure that the premises for niche formation are present: "the choice of technology, the selection of an experiment, the set-up of the experiment, scaling up the experiment and the breakdown of protection by means of policy" (p. 186). These steps will not need a broad elaboration here, as most of them are given premises and already incorporated into the Demo 2020 programme[16]. Kemp et al. also warn against if these steps are followed too mechanically:

> "...the reflexive side of strategic niche management and its primary aims would be degraded. The primary aims of strategic niche management are stimulating learning about problems, needs and possibilities of a technology, building actor networks, alignment of different interest to a goal, altering the expectations of different actors and fostering institutional adaptation; the steps are just a way to achieve this (p. 189).

Therefore, these steps are included in the discussion of the primary key process "project design" in the analysis chapter.

The subsequent key processes are coupling of expectations, articulation processes and network formation. Coupling of expectations concerns gathering of promises and expectations regarding the technology. Shortly put, the argument is that the better promises are shared distributed among actors, the more powerfully they will

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[16] I refer to this article for more details regarding these steps.

influence the niche formation process. If the promises concern problem-solving compared to technologies in the existing socio-technical regime, this will further strengthen expectations.

Articulation processes concerns learning dimensions within and outside the experiment. The goal for articulation processes is to overcome “a number of barriers to the introduction and use of a new technology” (ibid., p. 190). Network formation is neither less important. A strong actor network is needed to develop the niche sufficiently. This should be pursued by taking care that the network is broadly created, with institutional and societal as well as industrial actors. The learning- and network formation processes are highly multi-dimensional, and will be broadly elaborated in the analysis.

4 Research design and methods

In this chapter follows a brief description of the procedures conducted to carry out the research in this thesis. It is the given research design and methods that lays the premises for how the findings are systemized and ordered to conclude with a hypothesis or policy recommendation (Yin 2009). To map all the findings of relevant empirical material has been a challenging task. As different companies have made individual alliances with others in a pattern that was initially difficult to navigate through, it has concerned a large amount of workload to filter out what could be counted as relevant for the study object and what hasn't.

4.1Research design

The case study provides an opportunity to use a variety of different data. The benefit of this is that these can fulfil the gaps of each other, which overall may present an empirical object that can lead to a broad understanding of the case. Furthermore, if the case leads to findings that resemble different cases with the same kind of theoretical framework, these can provide a stronger conclusion and recommendation for further research and possibly policy guidelines.

The benefit of using various types of data collection is that the findings can overlap each other and thus verify that the sources maintain reliability. Data of various types has different strengths and weaknesses, but the more types of data and the more data, the more overlapped and reliable may the findings and the outdrawn conclusions be (Yin 2009). However, data collection should ultimately be limited to not include too much information that rests within the grey area between the core subject and contextual or parallel developments. This may complicate the analysis part as the study object may become too blurry, thus not presenting a clear outcome or conclusion.

I have primarily used interviews and document data for this thesis. In addition, I have attended different conferences and meetings discussing overall challenges and possibilities for the industry. These include the seminary “Vindkraft fra A til Å” by Tekna 2009, The annual meeting of Norwea (The Norwegian wind power association) 2010, the University of Oslo’s Petroleum Day 2010 and NEREC 2010 (North European Renewable Energy Convention). By these participations I have collected valuable contextual information, and had the chance to speak with important key people in the business.

Nonetheless, the activities and plans in the OWP business are enormous, both nationally and internationally. These plans are often embedded in an overall public renewable energy programme, often incorporating neighbouring activities like tidal, wave, solar, osmotic power and so on. As the development goes so rapidly, unfortunately it will not take long time before the technological development and political context will become slightly outdated. This must be bore in mind by the reader, as (semi-)radical innovations may turn around expectations and thus influence the socio-technical landscape.

Interviews

I have focused the study object around the core actors constituting Demo 2020, and key personnel from these have been interviewed. These key representatives constitute major stakeholders of OWP in Norway. More precisely, the four initiative actors have contributed with their version of their understanding of Demo2020. Several of the key personnel here hold different positions as board members as well as representing their mother company. The Norwegian Wind Power Association has presented their objects and expectations for the project. I have had several informal conversations with the secretariat, in addition to one formal interview. Statoil has been addressed by their participation in the Demo Rogaland project (as well as being an important actor internationally by the development of the Hywind turbine), alongside with Lyse and GE. The latter has not been included to the interview sessions. Although GE's role in this project is indeed interesting, their contribution consists mainly of delivering a fixed (although newly developed) hybrid turbine design, according to the informant in Statoil, a relatively given design, GE was eliminated from data collection due to limitation reasons.[17] As for Statoil, their role may be more interesting (particularly in the future) as an important institutional actor, given their highly sophisticated knowledge on offshore institutional as well as operational matters. Finally, when the work of the thesis came to its finalising phase, the snowball method made it interesting to speak to the Norwegian board of technology (Teknologirådet in Norwegian), as it turned they are working on a policy recommendation very similar to the recommendations I will briefly outline in the analysis and conclusion chapter.

The interviews were conducted in a semi-structured way with a basis on the core processes, but with an open view to gather relevant information initially not thought of. The interviews were conducted in Norwegian, and were successfully transcribed and

[17] Of course we cannot take for granted which possibilities that might have a potential through the Demo Rogaland demo project. Although the shareholders claim that D. R. is limited only to technology verification purposes, its test phase might discover potential innovation breakthroughs that could lead into a significant need for further R&D, to pursue mature technology development.

translated to English. I have made my best efforts to translate as clear as possible, but it should be noted that the translation usually cannot be done directly, rather contextually.

The following interviewees are:

Andreas Aasheim, advisor, Norwegian Wind Power Association (NORWEA).

Jan Onarheim, director at CEER Nowitech (NTNU).

Mette Kristine Kanestrøm, project manager at Lyse Energi and board member for Arena Norwegian Offshore Wind.

Viggo Iversen, project manager at Proneo, manager of Arena Windcluster Mid-Norway.

Kristin Gulbrandsen Frøysa, research director at CEER Norcowe.

Torgeir Nakken, advisor at Statoil renewable energy section, responsible for the Demo Rogaland project.

Jon Fixdal, advisor at the Norwegian board of technology.

Document and news article review

Although the interviews has been important, filtering contextual macro data would have been almost impossible without a substantial workload on mapping the empirical object and major trends in the industry. A considerable amount of time has been spent on this work. Reading white papers and press releases from several ministries has given me the relevant input for understanding the role that the authority institutions have played in OWP development. Newspaper articles and Teknisk Ukeblad, an important technical weekly magazine has also provided substantial input to the case as well as the overall energy business.

4.2 Data analysis

A vast amount of empirical material has been filtered and analytically induced down to the core key processes as presented by the framework. This systematization of collected material can be said to be part of the analysis. To guide this process, the research question provided guidance in how to move forward and structure the material. Furthermore, SNM literature and case studies has provided very important inputs for giving me a cognitive framing of how to think and analyze "SNM-wise." Discussions with my supervisor as well as informants and other stakeholders with substantial knowledge within the wind power business have helped this process.

4.3 Validity and reliability

The validity and reliability of a master thesis concerns the research quality and its findings. To assure validity, there must be a connection between the theory and the findings presented in the analysis. If these fits well into the theoretical framework, and resembles earlier research done with the same theory, then reliability is also adequately maintained (Yin 2009). The understanding of earlier SNM research and the framework has given me input in how to proceed in collecting data and designing the analysis, thus assuring validity.

Reliability concerns whether the findings are trustworthy and may be repeated by another researcher. I have assured reliability through describing the work process in this chapter, so that the research may be replicated (ibid.). To assure validity, it is important to examine how the findings are relevant to the theory. This is thoroughly confirmed throughout the analysis chapter.

5 Analysis

The vast amount of empirical material collected will be scrutinized and analysed in this chapter. From basic SNM theory – it was initially clear to see that the DEMO 2020 initiative has evolved out of a common need – but has been managed quite fragmented. Thus, the findings indicate that *strategic niche management thinking* is not abundant in the Norwegian business. Rustad (2009) has made similar findings in the Carbon Capture and Storage business (CCS). However, due to the many difficulties encountered by the developers of CCS and the Norwegian forefront role pushing this development further – at least has the state created Gassnova, an agency to manage the public interests and aiding the development of large scale CCS at the gas power plants at Kårstø and Mongstad. Nonetheless, it is fair to say that also this business has encountered numerous problems on its way across the "valley of death", but these are to a greater extent linked to major technological challenges, like serious health hazards (ibid.).

There are many procedures to analyze technology development through the SNM framework, and this can be a difficult task, providing that different technologies represent and respond differently in different contextual landscapes. SNM scholars emphasize that sticking too rigidly to a strict recipe for analysis, may be harmful for a suitable measurement of the respective case. Thus, they stress that the analysis should maintain a degree of elasticity to fit the empirical object as good as possible (Kemp et. al 1998, Schot & Geels 2008). After all, the SNM study object is (usually) constantly evolving in new directions, given that actors within the network influence each other continuously, as well as the occurrence of new actors and influences from external developments. This said, it is hard to find a suitable starting point by favouring one set of scholars above others. Still, Kemp et al.'s four key processes are a good place to initiate the examination, giving a reasonable starting point for an SNM analysis. Their procedures has later been criticized for lacking an overall societal landscape dimension (see e.g. Raven 2005), but I will bring this discussion into the last part of the analysis chapter.

5.1 Project design

This "key process" is a sum-up of the five steps of the basic settings required before the actual niche formation takes place, as outlined in the theory chapter. The Demo 2020 project is given certain specifications for how it is planned, and the basic premises are thereby set. It is therefore not necessary to go into details of why this technology has been picked, set up, scaled up and specified (Kemp et al. 1998, Caniels & Romijn 2008). In this context, we take for granted that the experts involved in designing Demo 2020 has thought about every critical component in the experimentation programme that is included in the project, as it is presented as a fully integrated test programme. As the initiators wrote in the notification to the ministries:

> We argue in this notification for the necessity of a national test and demonstration programme to give the industry necessary references to be able to qualify for deliveries to the European markets. At the same time, a programme like this will be required to commercialize and industrialize the R&D results from the research centres involved [my translation] (Norcowe 2010, p.1).

It is therefore more interesting to look at activities within offshore wind development plans prior to Demo 2020, and why these have obstacles needed to be overcome. After all, this is partly why Demo 2020 has been developed. The empirical material has shown that many actors are striving to influence the shaping of OWP, and thus the conceptual premises. This is particularly connected to the network formation process, which will be discussed later in the analysis. What has been obviously clear by the initial findings though, is that several actors have, for a long time been working with their own plans for offshore wind farms and smaller scale demonstration projects. One of these actors are Vestavind Kraft,[18] which also through the branched off company Vestavind Offshore has bought the 350 MW Havsul I (Which is the single remaining bottom-fixed wind farm out of four to be further developed of the study object analysed by Thele 2006). Vestavind Kraft was granted concession from NVE in 2009 for three demonstration sites at Stadt, thus giving experiences to their much bigger plans for Stadtvind. However, this project site is situated in deep water below 100 meters, and relies thus entirely on the R&D of floating technologies, which probably need at least half a decade to gain enough maturity before rough testing can start at the Stadt project. The Havsul I is however, closer to implementation and planned to be developed in two stages. The first stage comprises 50 MW, and is considered to be a knowledge and technology build-up phase, thus allowing for *trial-and-error* and *learning by doing*. The remaining 300 MW development will not become initiated before the first phase is thoroughly evaluated and completed[19]. Before this can start up though, the concept, partners and specifications need to be further developed. Vestavind Offshore are seeking such partners, and have not signalled any concrete time scale for when implementation can

[18] Owned by several wealthy hydro power companies in Western Norway, including Tafjord Kraftproduksjon, SFE Produksjon, Sunnfjord Energi, Sognekraft, BKK Produksjon, Sunnhordland Kraftlag Produksjon and Haugaland Kraft.

[19] http://vestavindoffshore.no/havsul

start.[20] Nord-Trøndelag Elektrisitetsverk and Nord-Norsk Vindkraft are among other actors who also have plans similar to Havsul I, although smaller in scale.[21]

Nevertheless, efforts in getting political attention for such plans have taught the industry that a national joint initiative is needed to address focused attention from the authorities. Kristin Guldbrandsen Frøysa, project responsible of Norcowe explains the formation of DEMO 2020: "The initiative came from the industry, Arena Now, Windcluster Mid-Norway and Norsk Industri. Onarheim at Nowitech was also very active when the notification to the ministries was sent." The project is designed in such a way that it will hopefully attract more attention from the authorities, and the signals from the Ministry of Oil and Energy (MOE) express that they are interested. In May 2010, State secretary Sigrid Hjørnegård in the ministry initially replied this to the invitation: "We are very, very positive... and very engaged in the question concerning offshore wind power and very pleased to get a request from the specialist environment"[my translation][22]. However, five months later and after the release of the government budget of 2011, it is clear that the response from the authorties are still unclear and non-committal (TU 32/10).

Concluding remarks

The initial discussions of Norwegian OWP plans presented in this section has shown how important it is to stress and manage a joint initiative to gain implementation. The main benefit for Demo 2020 is the connection between the industry and R&D

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[20] http://www.windenergie-agentur.de/deutsch/aktuelles/WAB-Veranstaltungen/Studienreise-Norwegen/PDF/12_Vestavind_Offshore_Engevik.pdf

[21] Source: www.nve.no

[22] http://www.bt.no/nyheter/lokalt/--Vi-er-veldig%2C-veldig-positive-1040923.html

environments. Still, there is a long way to go to create a prospective momentum in which the authorities are willing to contribute. If and when this contribution takes place, this will reinforce the processes for niche formation, creating a market for contractors as well as subcontractors, raise expectations and reinforce network formation. The aspects for further investigation of this will be elaborated in the subsequent sections, concerning the core processes for niche formation.

5.2 Coupling of expectations

Kemp et al. (1998) defines coupling of expectations as one of the core processes constituting niche formation. "In the early years of development, the advantages of a new technology are often not evident. Their value still has to be proven, and there are many resisting forces" (ibid., 189). It is therefore necessary to raise expectations for the technology, in the existing socio-technical landscape, adequately enough to give the technology a chance to influence the ruling regime.

Expectation build-up for Demo 2020 has happened through the acknowledgement of the joining of forces to make a common initiative, to gain needed political attention. During the last years, we have seen several efforts of individual proposals for demonstration OWP projects in Norway (Norwea 2010). With the creation of the two CEERs for offshore wind research in 2009, the debate slowly started to turn into proposal for a *joint* initiative. However, by interpreting the consensus for developing bottom-fixed demos in Norway, it is fair to say that prior to the Demo 2020 initiative, few spoke of a specific need for the testing of Norwegian OWP technology within the country borders. The industry has for a long time invested time and resources in selling and testing their technology abroad, and there has been a common acknowledgement that the market for such testing and serial production is not interesting in Norway. A leading actor of turbine tower fundaments, OWEC Tower (a member in the Arena NOW network), has demonstrated their product in both the Beatrice demo in Scotland, as well as in the Alpha Ventus park outside Germany. The summer of 2010 Aker Verdal (in the Windcluster Mid-Norway) won a significant contract of delivering no less than 48 jacket foundations to the Nordsee-Ost wind farm in Germany.[23] This achievement is the result of a generation of accumulated know-how, expertise and spin-offs by the Norwegian offshore supply industry, widely regarded as product champions within subsea and specialized offshore structures. Before the industry and research agencies agreed to join forces, there was little attention to the creation of national strategies for bottom-fixed OWP development. The success that certain Norwegian companies already has experienced abroad, might have distracted actors from paying significant attention to the time lag between the development in Norway and EU. The ministry of Oil and Energy turned the attention in Norway to the development of a new maritime legislation, *Havenergilova* (see for instance Benningstad 2009 for more on the subject), stating that OWP development in Norway would have to wait for more mature technology to be available.

Although land-based wind power development concerns a slightly different trajectory path technology-wise, what happens in this department is not irrelevant for the OWP development. The actors concerning land based wind power are expecting raised support through the implementation of the TGC support scheme from 2012, and also an obligation for increasing of the renewable energy production through the EEA

[23] http://en.wikipedia.org/wiki/Nordsee-Ost_offshore_wind_farm

renewable directive. Concessions given from NVE is corresponds to 6 TWh, but not all of this can be implemented financially (Norwea 2010). Nonetheless, by the expectations given through the planned TGC scheme, this will after all reinforce the process.

When Statoil and Statkraft along with british actors through the consortium Forewind won the record breaking Dogger Bank field development in January 2010, this provided a change at the landscape level and paved the way for a newly perceived paradigm of what can be achievable within Norwegian wind technology and knowledge supply. With this as contextual premise, the Demo 2020 initiative has evolved as a pragmatic response to the acknowledgement that Norway is lagging behind the European development, fuelled with the demand for references required for participation in projects in the British and German part of the North Sea (Norcowe 2010). Mette Kristine Kanestrøm in Lyse Energi / Arena NOW explains: "Demo 2020 concerns pre-qualification of Norwegian technology and actors for a potential participation in Dogger Bank and UK round 3."

Demo Rogaland

Nonetheless, the last year also saw the introduction of a massive global actor of wind power in Norway. With the acquisition of Scanwind by General Electric (GE), it became clear that the giant somehow was expected to invest heavily in this Norwegian particular wind turbine development, well suited for rough arctic climate. In March 2010, GE announced significant plans for a heavy industrial participation and investment around the North Sea basin, which for Norway's part meant relying on Scanwind's site in Verdal as a base for demonstration unit production and testing (GE Energy 2010a). Simultaneously, GE started working individually in search for industrial partners and a suitable demonstration site. Statoil stated early that they were interested in such a partnership. Lyse Energi (based in the oil capital Stavanger as well as Statoil) has worked for a couple of years with plans for offshore demonstration projects, notably through a Sway demonstrator, but also bottom fixed.[24] They therefore already had plans that easily could be adapted to fit GE's search for partners and sites suitable for their announced 4MW offshore turbine testing, benefiting from the gearless design from the Scanwind technology. In the end of april 2010, Statoil, GE and Lyse announced plans for a joint demonstration park in the waters outside Rogaland, with likely two to four turbines (Lyse 2010). Kanestrøm elaborates on these plans, called Demo Rogaland, and its connection to Demo 2020:

> Demo 2020 is a work programme, an invitation in which it is essential that the authorities are participating heavily. Demo Rogaland is on the other hand much more concrete, with plans for concrete GE turbine testing for pre-qualification of technology to compete in the Dogger Bank competition. We have been working with these plans independent of the Demo 2020 project.

By the introduction of this concrete project, one can argue that expectation process for the creation of a joint public supported demo program have been weakened by the shortcut of a few actors. It should be needless to say that Demo Rogaland might end up as the final outcome for the first round of bottom-fixed turbine demos in Norway. Lyse, Statoil and GE expects to make a final decision on development during next year. The implications of this project may be substantial, and details regarding its network formation and possible articulation processes will be discussed in the subsequent sections. Viggo Iversen, manager of Windcluster Mid-Norway also suggests this when asked about his view of the prospects for Demo 2020: "I'm not sure if Demo 2020 will be

[24] http://www.aftenbladet.no/innenriks/okonomi/article461893.ece

carried out in the form in which it is presented now. But I do believe that some sort of demonstration project will be initiated within the near future." Many of the informants expressed similar concerns, blaming the policy support scheme and the ambivalent response from the ministries as the main obstacles for the project to gain adequate attention from the authorities. The sheer size and wealth of the companies[25] comprising the Demo Rogaland project makes it reasonable to assume that they have a better chance to carry out this project due to substantial financial muscles.

An expectation coupling dilemma – choice of technological trajectory

Key actors playing a role in the shaping of expectations for OWP development in Norway, might threaten a uniform goal of *bottom-fixed wind turbine testing* by introducing different concepts and technologies into the public debate. The data collection shows clear signs that this has become a major threat for the Demo2020 programme, and has possibly challenged its prospects. This concerns, among others, several concepts of wave and tidal power proposals (Norwea 2010). However the most significant concrete competitor within Norwegian shorelines at the time of writing is the further development of the Hywind turbine. This single floating full scale turbine, first in the world, is already a proven success, and has produced electricity to the grid in Rogaland for nearly a year (TU 29/10). Åslaug Haga, director in Norsk Industri calls for an extraordinary public engagement to support the proposed Hywind II project. In order to make sure that the next large scale testing phase of this project will happen in Norway, she makes it clear that substantial financial support must be raised from the

[25] See Lyse 2010, GE Energy 2010a, for instance. GE's investment plans for wind technology in Europe, 2,7 billion NOK, speak for itself.

authorities to compete with the offer that the Scottish government has already proposed to Statoil as an invitation of Hywind II to Scotland (ibid.). Although this engagement obviously is a benefit for Norwegian OWP industry in an overall perspective, it does not provide any direct benefit for Demo 2020, more of the contrary. Thus, it might become a matter of choice, whether politicians in Norway wants to prioritize the creation of a national champion team of either *floating* or *bottom-fixed* OWP technology. It is probably follows uncertainty whether the government may raise financials to fund both initiatives. The Hywind II project is expected to include three to five Hywind units, and the necessary grid and infrastructure to tie the components together (TU 25/10). This is not very unlike the DEMO 2020 concept proposal, although in a floating arrangement, and probably containing relatively similar subsea installations for transformation and transmission components. A development of Hywind II in Norway could thus create a *technological trajectory dilemma*. In SNM theory, it is argued that more local projects create deeper network formation and regime integration. This dilemma is thus two-fold. The more R&D activity of OWP development, the better overall learning processes and necessary regime influence. On the other hand, it is a given fact that developing offshore wind power technology is an immensely expensive activity. It is difficult to see if the Norwegian government would be willing to fund both initiatives, given their reluctant response to Demo 2020 in the first place. At some point, selection of a technological trajectory pathway has to be decided upon, given the extremely high costs both of development, as well as the deployment itself.

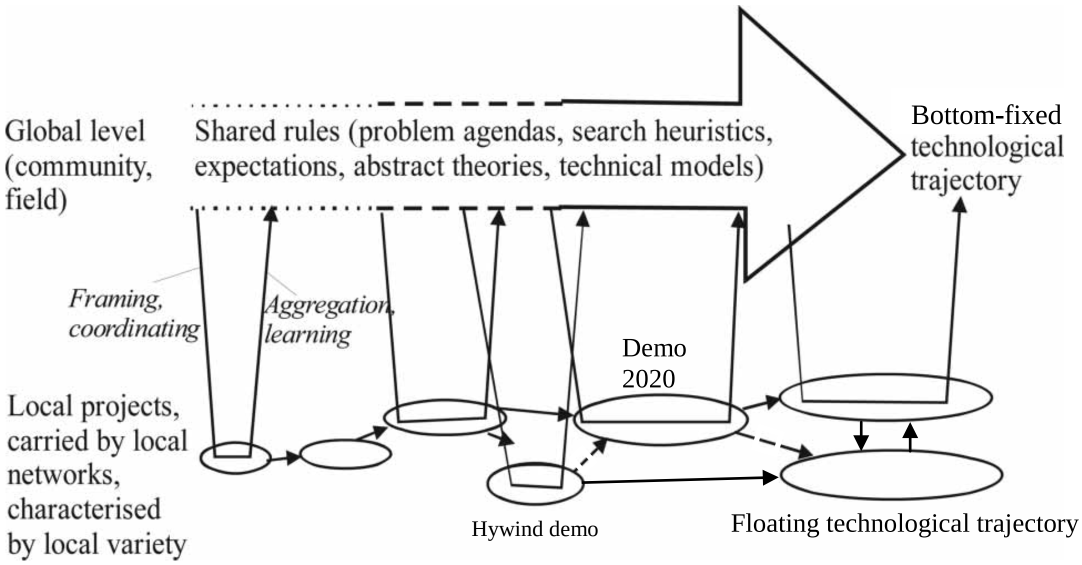

Figure 3. Emerging technical trajectory carried by local projects (modified from Geels & Raven 2006, 379).

Fig. 3 is a slightly modification of a figure from Geels & Raven (2006), showing how Demo 2020 and the Hywind II demo may create two diverging technological trajectories, bottom-fixed and floating respectively, although the projects may interactively influence each other. The arrows between the trajectories suggest that learning may be shared, particularly for general offshore operations. The dilemma as outlined above is mainly connected to financial issues, whether it is economically feasible for Norwegian authorities to support both initiatives, while mutual diffusion of articulation processes are positive regardless of outcome. Many of the informants implicitly suggested however, that the Hywind II project might probably end up in Scotland due to the ambivalent response from the Norwegian authorities.

Concluding remarks

To sum up the shaping of expectations: Prospects for development of offshore wind power in Norway are characterised by a high level of activity and broad expectations, particularly considering the already present successful entrance of Norwegian actors in British and German waters. Actors share opportunistic visions of substantial achievements both technologically as well as institutionally through strengthened knowledge milieus and expected accumulated know-how build-up. Statoil's Hywind floating demo is already regarded internationally as a success, creating a positive attitude in spite of heavy costs. When GE entered the wind industry in Norway last year, this brought a not-before-seen financial commitment to the development of OWP technology in the country, boosting expectations further and seeing the implementation of a first demo plant one step closer. The range of activities may also very likely have positive implications for cost reductions and development of land-based wind power. However, prospective activities might be challenged by a financial dilemma for supporting different promising trajectories, unless a substantially new policy scheme will be initiated.

5.3 Articulation Processes

Articulation processes are an important part of niche formation. By articulation processes we refer to different dimensions of learning – in which important aspects to mention are: technical, managerial, economical, cultural, social, cognitive, psychological, network and market learning. These processes are most easily endeavoured through experimental projects. "Experiments are a way to stimulate articulation processes that are necessary for the new technology to become socially embedded… Learning – about needs, problems and possibilities – should thus be an important aim of niche management...” (Kemp et al. 1998, p. 190). Experimentation-based learning can thus be achieved within all the dimensions aforementioned. I will discuss three of these aspects deeper, as they are probably the most relevant for Demo 2020.

Technological learning

The technological learning processes that the Demo2020 initiative opens up cannot be underestimated. “It can take considerable time, even decades, for an infant industry to become established and able to compete internationally. Moreover, maturation requires intensive technological learning” (Caniels & Romijn 2008, p. 259-260). Fortunately for this case, a large degree of relevant know-how is already present in Norwegian industries; it only needs to be reconfigured and canalized in the right direction. Given the technological lead possessed by the neighbouring countries, minor gaps or shortcomings of technological components or know-how may be acquired from these, thus minimizing the critical time-and-travel-related transaction costs related to *catch-up* to their knowledge-base level (ibid.). The learning processes that the project may endeavour are quite easy to identify. These are loosely defined in the official notification paper sent to the ministries. The paper pays particularly attention to already accumulated offshore industrial knowledge, arguing for a further development and new utilisations of existing technologies. Steel and concrete foundations are part of components that already has been used and specifically designed for the purpose. There are still more full scale testing to be done on these, particularly for concrete monopole foundations. For turbine development, experimentation with various concepts of component replacement and re-configuration is an important part of the learning processes. It is opened up for several turbine types to be deployed within the same park – and these may mutually share learning processes among them. (Norcowe 2010).

Particularly efforts for the lowering of top weight through different concepts of gearless configurations and the placement of generators near the shoreline has obvious advantages of being tested out on different types of turbines within the same park. Breakthroughs in turbine design are expected to happen by this development, bringing the weight and costs down, highly needed to make (offshore) wind power more affordable and attractive. This aspect certainly opens up for creating state-of-the-art technology through Norwegian components development. The same can be said for subsea, power transmission systems and cable technologies applied in new configurations. Even land-based turbine development may benefit from these experiments. However, an integrated system encompassing all the components in the value chain is yet to be planned and developed. This is probably the most important short-term learning process for developing skills and operational experience in delivery of a complete package for the tender processes soon to become concrete in the UK through the Dogger Bank field and the so-called round 3.

Among the CEER's contribution to technology and competence articulation processes is an already proposed and fully financed weather and ocean observatory and small scale test turbine to be developed by Norcowe and Nowitech. Better understanding of the physical forces in which these environments will operate – will help fine tuning the technologies to deliver optimum performances, particularly in rough climate. Guldbrandsen at Norcowe explains: "This observatory gives access to weather data and makes us able to compare how the turbine responds to different conditions, and different ways of controlling it". It is still a long way to go and thus too early to say if the centres will contribute to any breakthroughs in this segment. After all, meteorological towers and test turbines are installed throughout demo parks already – particularly at the Beatrice field in the UK and Alpha Ventus in Germany (Earthscan 2009). However, the Norwegian R&D milieus have a climatic competitive advantage – the ocean areas outside Stadt on the western coast of Norway represent some of the harshest weather conditions in Europe (Time 2006). The integration of research centres and industrial actors through Demo 2020 thus means an ideal connection for transfer of applied research results into industrial realization.

Statoil was addressed to give their views on learning processes through Demo Rogaland. Their project manager Torgeir Nakken gave this status report for their work on this:

> Demo Rogaland is running according to the plans… it's in the feasibility-stages and we just received concession from NVE. We're finishing the seabed survey these days, and expect to make a decision on which site to choose. We're working on picking the proper foundation type as well, and the turbine is of course given, which is GE. Statoil's responsibility here is connected to the marine operations and that's where we possess the knowledge and experience… Statoil is to a relatively small extent integrated into the Demo 2020 project.

Basically we can see that expected learning processes connected to Demo Rogaland has certain limitations compared to Demo 2020, when it comes to testing different technological set-up like for instance different turbines. Further, he expressed that R&D activities are generally limited in Demo Rogaland:

> We have a clear plan for what we should achieve before pre-qualification which is the goal of this demo. But within this, if anyone wishes to do other things on these plants, there are openings for that. But the main goal is the qualification of the turbines. It's not a R&D project in that respect…

Thus, Demo Rogaland partners signals a weaker integration of broad-level technological articulation processes than Demo 2020. If Demo Rogaland turns out to be the final implemented outcome for the first round of OWP demonstration projects in Norway, then the learning prospects (and the network formation) will suffer from poorer knowledge accumulation and shallower niche formation. This is unless respective public stakeholders demand some extent of participation, particularly connected to the activities in the CEER's.

Societal and institutional learning

Equally important among articulation processes within SNM theory are the societal learning processes. I have generalized many of the abovementioned dimensions here to be able to discuss these without elaborating too much on details. We can define these dimensions as efforts of institutionalization of the knowledge base that will be built up by such a demo programme. The economy involved in this large scale project will connect a significant number of actors from the whole value chain. It is particularly important to pay attention to learning trajectories that may be codified and embedded into industrial as well as societal institutions. With a total budget of 2 to 4 billion NOK, there will also probably be great opportunities for the teaching institutions and local university colleges to become embedded by educating OWP trained personnel specifically. Land-based wind power has a long trajectory development still to be pursued in Norway, regardless of the offshore development. It is likely that knowledge build-up may thus lead to spillover effects between on- and offshore wind development in this respect.

Nevertheless, a large degree of the societal and organizational articulation processes cannot be transcribed and codified. Caniels & Romijn (2008) indicate that embedding new knowledge that follows new technology into the workforce involves that a lot of the cumulative knowledge transfer is:

> …tacit, and also since local conditions with respect to markets, raw materials, climate, etc. differ from the conditions under which the technology was originally developed, the road from installation to efficient production tends to be beset with numerous problems. Mastering these problems involves a prolonged process of learning, which requires a sustained commitment of financial and human resources towards technological debugging and adaptation (p. 260).

This implies the need to develop a strong agency that can understand and manage such processes. Hence, this is a clear policy recommendation, to assure an adequate industrial and institutional build-up, and development towards a desirable regime change. It is then particularly important to emphasize that the learning processes must be picked up and monitored on a broad level, and that they are not limited to R&D activities which Norwegian policy development have suffered from (Fagerberg 2009b): "Although a lot of these activities do not qualify as formal laboratory R&D, they do constitute applied and shop floor-based search and research, driven by concrete obstacles that manifest themselves on the job" (Caniels & Romijn 2008, p. 260).

Articulation of cultural and psychological meaning

A large amount of studies has evaluated the gap of impressions when it comes to the symbolic meaning of green/clean technologies in general.[26] Environmental business

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[26] I refer to Thele (2006) and Jakobsen (2008) for a relevant further elaboration on this.

attitudes are, for marketing purposes, exploited as far as possible. Generally businesses want to be associated with taking their environmental concerns serious. For instance is Toyota well known for TV commercials advertising how much they care about environment when designing the next generation cars. They claim that their newest Prius model represent ”harmony between man, nature and machines”.[27] The Norwegian State Railroad Transportation Company ran heavy adverts claiming that Norwegian trains run solely on clean hydro power, arguing that railroad passenger transport is the environmentally friendliest transport solution.

In the same breath, wind turbines are a highly popular icon displayed in adverts by companies concerned about finding new sustainable solutions in general, even if they are not necessarily working with environment issues at all. “The picture of wind power as environmentally sound is one of the industry’s most valuable assets” (Thele 2006, p. 17). In a recent proposal for a zero emission hotel planned in the woods north of Oslo by investors and the newly created CEER Zero Emission Buildings, energy will be created by a integrated bio fuel plant, as well as a 30 metre high windmill.[28]

This example is one of many signs of a consensus shift, emphasizing the visual impact of wind turbines less negatively. It can partly be linked to a broader societal acknowledgement of the necessary impact consequences of developing and deploying renewable energy plants. Ina Jakobsen (2008) has studied attitudes towards wind power in Denmark, and discussed the differences in consensus. She shows here how legitimacy for wind power development is carefully embedded into an overall

[27] Source: Toyota Prius “harmony” TV Commercial, http://www.youtube.com/watch?v=Tq4nrmnqY9o
[28] http://www.aftenposten.no/nyheter/oslo/article3637979.ece

sustainability plan, in which residents and authorities jointly share a common comprehension of necessary action, thus accepting the negative visual impact – even recognizing this visual impact as positive by seeing the “environmental beauty” in the wind turbines.

As mentioned above, we gradually see a similar trend in Norway. The heavy marketing of sustainable solutions like these (either they concerns driving hybrid cars, taking the train, consuming renewable energy or transporting this energy) helps the articulation process of creating deeper legitimacy for needed new sustainable solutions, thus creating a greater willingness to accept the negative trade-offs these solutions necessarily demand. This translates to the cultural dimension of the new configuration breakthrough as presented in figure 2, on the regime level. The vast amount of proposals of local projects discussing such sustainability plans – including Demo 2020 – mutually reinforces the articulation processes connected to the re-shaping of cultural meaning. Eventually occurrences within the cultural as well as the other dimensions together facilitate necessary adjustments of the socio-technical regime.

Concluding remarks

Possible articulation processes abound throughout renewable energy development in general and OWP specifically. The technological learning processes are particularly numerous. These can foster a large number of spin-off activities and stakeholders following the expectations outlined in the above section, and thus reinforce the process of adding accumulated knowledge. However, the outcome of which project to be the first implemented can create certain boundaries related to this. Learning processes within institutional development is probably the most challenging aspect in this respect, as this demands creation of new specific agencies, which have to go through necessary phases of trial and error. Articulation processes of psychological meaning still needs to be developed, as wind power has struggled with massive local opposition. Nonetheless, a new OWP trajectory may create opportunities for a re-shaping of opinions.

5.4 Network Formation

An overall view of the institutions and actors encompassing the Demo2020 project indicates the need for a strong leader with a managerial role to guide and steer the project in a uniform direction. This is needed to maintain a clear-cut scope, communication and participation with the national authorities, where the overall goals are precise and clear. During the interview with the member organization Norwegian Wind Energy Association (Norwea), it became clear that the network formation process has shown signs of lack of clarity and uniformity. Adviser Andreas T. Aasheim explained that the cooperation process has not been without difficulties, and that Norwea more or less became pushed out to the sideline:

> "...there have been some conflicting interests maybe. In our view, we were supposed to have the responsibility for what we may call the lobbyist activities, but suddenly someone else started running around in the hallways in the Parliament..."

Norwea expressed reluctance to elaborate more on the subject, unwilling to tell who was taking matter into their own hands. Regarding their position as an interest organisation representing wind power activity in Norway, this is understandable. In an interview with the director of concessions at NVE, Arne Olsen, we are able to get a better understanding of how the wind energy business in Norway has developed, since the deregulation of the market and the creation of the energy act in 1990:[29]

> -The wind power industry actors have probably fallen for the temptation to take part of an unrestrained desire for project proposals. This concerns the conquest of land. Everyone has been chasing like a pack, but a majority have ultimately been facing the fact that there are strong limitations to what you can integrate into the system... The Klondyke- atmosphere has become our problem... [my translation] (Norwea 2010, p.12).

Norwea also suggested that the ruling business model is the *first come, first served*-principle. This indicates that the creation of a uniform actor network with uniform goals is difficult. Jan Onarheim, vice director at Nowitech emphasizes this as one of the major goals of DEMO 2020: "*The Demo2020 project is an effort to overcome localisation issues, and jointly propose a common plan to the authorities."* This expression was shared by Mette Kristine Kanestrøm representing Arena NOW as well, but they both stand in contrast to the findings above. These statements indicate that there are unspoken strong local forces seeking to get projects established in their home community.

Altogether, there is therefore reason to assume that local industrial actors (probably representing some of the Arena constellations) have been willing to shortcut the political process of whom to get the attention from the politicians. It can thus be argued that dismissing Norwea from the role as an overall organising actor for a common test- and demonstration plan has been unfortunate. From the SNM theory, Kemp et al. (1998) states:

[29] Thele 2006.

> It should be noted, however, that just like normal management, niche management is not the purview of a single actor but a collective endeavour. Niche management policies are the collective (negotiated) outcome of different interactions at different levels. Some actors, however, are likely to take on a more dominant role as niche managers than others, and may therefore be called “niche managers”. The niche manager may be a person or an organization (p. 188-189).

This argument can thus be interpreted to-fold. If the project is firmly supported by financial bodies (which may be the authorities as well as wealthy investors), it is desirable that an agency proposed by the government gets the managerial role, to maintain the overall strategic goals. However, before such a project is firmed and under protection by a national program, it should be an interest organisation not being biased in any localisation issues. Norwea could therefore ideally serve as a manager pushing this project forward. To this date, there are no concrete offshore wind power plans in the south-eastern region of Norway, providing Oslo-based Norwea with relative neutrality on the matter.

Two research centres for offshore wind power

The Norwegian Research Council (NRC) conducted and financed the formation of eight research centres for renewable energy (CEER) in February 2009 with the aim of creating areas that contains concentrated, focused and long-term based research (Bugge, Godø, Midttun, Pedersen & Spilling 2010). This should keep up with high international standards seeking to solve challenges within cleantech industry and renewable energy. The activities in these centres have a time span of eight years. In addition to the funding from NRC, the industry has been invited to support additional financials for specific research packages directed to their respective activities. The political support to the CEER creation came through the so-called *climate-compromise* in 2008, in which the authorities agreed to initiate concrete action for the development of Norwegian state-of-the-art technology that would help facilitate climate friendly solutions. As is usually the case when Norwegian authorities present large scale (and often fragmented) R&D projects in Norway, localisation of such centres follows a decentralized pattern (Fagerberg 2009a). However, this time the centres (or the mother institutions of the centres) are localized in the three largest university cities, with four CEERs in Trondheim, two in Bergen and two near Oslo (Kjeller and Ås) (Bugge et al. 2010). This reflects the connections and activities of the respective university milieus involved, and their historical commitment to entrepreneurial activities. Nowitech and Norcowe are led by the regionally important research institutes SINTEF and Christian Michelsen Research respectively, each representing "independent" spin-offs from university R&D activity[30], with a specific focus of commercialization strategies (Guldbrandsen & Nerdrum 2009).

Nonetheless, several research institutes within these centres are scattered throughout the country, with significant activities ongoing in Stavanger and Kjeller (Oslo) as well, comprising other historically important actors within energy research such as University of Stavanger (petroleum energy) and Institute of Energy Technology (IFE). The latter has played a major role in energy research in Norway within virtually any electrical energy source, ranging from nuclear energy in the 50ies to a heavy commitment in (photovoltaic) solar and wind energy today (ibid.). According to Bathelt et al. (2004), cluster theory suggests that certain geographical boundaries for the localisation of common activities must be maintained, to assure that knowledge creation

[30] Located at Norwegian University of Science and Technology (NTNU) and University of Bergen.

flows smoothly. A large extent of the knowledge exchange through such clusters happens through tacit or diffuse knowledge creation, and this creates certain limitations to the exchange of knowledge:

> Only by being in the same local environment, and by meeting repeatedly in person, can and will such more subtle forms of information be exchanged. This has been proposed as the main mechanism that makes it beneficial for a firm to be located in a spatial cluster, surrounded by other similar and related firms (p. 32).

Although these scholars focus regarding cluster theory circles around the localisation of firms, the same can be said about localisation of research institutions and thus, university-industry links as a whole. Hence, one may suggest that with such fragmented spatial extent of the network involved in Demo 2020, this can create difficulties for the diffusion of knowledge throughout the network. The point of argument is that, according to SNM theory, creation of only one single research centre for OWP could have given this the position of being more able to coordinate all activities and actors within the Demo 2020 workgroup, and absorb and codify all the accumulated knowledge. The same concerns the financials; the funding now canalized to two centres could have been used more effectively. On the other hand, this argument has thus two sides, as two centres have its advantages as explained by Frøysa:

> It makes very much sense with two centres, with different approaches. You are then able to pull from different resources, and the centres are very different when it comes to organisation. Sintef, NTNU and IFE have been working on this for a very long time [while CMR not so long]. Generally, there should be more centres [my addition].

The Norwegian sectoral principle

The Norwegian professor in innovation theory Jan Fagerberg has published several papers and books describing the weaknesses and shortcomings concerning the Norwegian national innovation system. In a recent report (Fagerberg 2009b) he sums up the innovation policies and systemic problems connected to this system. More broad details on this relevant to the case will be accounted for in the next section. What is relevant here is that some of the concluding recommendations from this report are to seek fewer actors involved in strategic large scale innovation projects, based on the fact that the sectoral principle in Norway leads to numerous disadvantages. By the sectoral principle we here understand that public economic activity are shared and spilt with "watertight doors" by respective ministries and their specific activities, which again fund their individually supported research institutes (known as the large Norwegian institute sector), [31] funding these specifically but also through the agency of the Norwegian Research Counsil (ibid., Fagerberg 2009a). One could thus argue that it is not unproblematic that the total budget funding for the OWP related CEER centres are MNOK 560, each 320 for Nowitech and 240 for Norcowe, and that they spend these funding with a great deal of freedom. Bugge et al. (2010) has evaluated the innovation and commercialization strategies and performances for all the CEERs so far. They indicate that the two OWP centres have "minor differences in focus and emphasis within R&D areas and technology development, but a substantial overlap and concurrence between the two CEERs" (p. 33).

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[31] Details on this is extensively outlined by Fagerberg 2009a and 2009b.

From a network formation perspective, and SNM particularly, one could thus argue that DEMO 2020 could benefit from having only one of these OWP CEERs to have the *managerial role* for a national test and demonstration program. When the CEERs became created, it seems that no one thought particularly about this issue. This is confirmed by Frøysa's argument for two research centres. During collection of empirical data, what became an impression led to the assumption that the Trøndelag region (Nowitech and Windcluster Mid-Norway) has the most concrete strategies for commercialisation and immediate technology testing (see Bugge et al. 2010), while Norcowe is working on a much longer time span suited for so far immature floating technology. This contains long-term plans for their ocean observatory, and is thus, less situated for pre-qualification which is the first goal of Demo 2020.

The Demo Rogaland Project

Amidst the managerial plans from the Demo 2020 initiators came the introduction of General Electric (GE) as a major OWP actor in Norway. The snowball then soon started to roll in terms of concrete test plans in the country, more than ever before. As described in section 5.2 this project has certainly good prospects when it comes to implementation, due to its wealthy owners. GE announced plans for investments in Europe of up to 2.7 billion NOK to take part of the offshore wind industry growth (Lyse 2010). This is their response to the expected massive consolidation of actors to take part of the major development plans soon to be initiated in UK and Germany. Their press release in March 2010 stated this concerning their plans in Norway:

> GE also has joined the Nowitech Research Centre in Norway to participate in joint research projects on offshore wind topics. Norway is the planned site for the testing and demonstration of the first 4-megawatt wind turbines offshore. This will result in approximately 100 jobs and a €75 million

> investment related to GE's offshore wind business in Norway by 2016 (GE Energy 2010a).

By counting the financial numbers, it is clear that this is a heavy industrial commitment. When GE explicitly noted that Norway is their planned site for a demonstration park, this may probably represent the most binding commitment we have seen for OWP development within Norwegian shorelines so far. However, as outlined in the previous sections, Demo Rogaland represents certain limitations within diffusion of articulation processes and a joint share of activities. Guldbrandsen Frøysa explain the CEER's commitment to this project:

> Demo Rogaland is a very concrete project, with testing of specific turbines to commence next year, by private actors. Demo 2020 is a completely different concept, a joint initiative with public and private finance scheme. But we are cooperating with Demo Rogaland, Lyse and Statoil are partners with us, and we share a common dialogue.

In Trondheim at the Nowitech centre, the managers have a more clear view regarding an inclusion of Demo Rogaland into Demo 2020. Project director Jan Onarheim has opened the door for cooperation, stating that he supports any demo programme implemented within Norwegian shorelines (Onarheim 2010). No formal agreement is so far made, but the dialogue suggests that there are possibilities for the CEER actors to become connected to this project.

Concluding remarks

The network formation process surrounding Demo 2020 shows that the actors have become deeply aware of the importance of cooperation and coordination. The design of the programme certainly makes its ability for strong network formation one of the best qualities of the project. When this is said, management of the project would have gained a highly needed strength if one manager would have been put in charge of deciding upon strategic choices and the marketing of the project to the authorities. There are clearly differences in the view of how tight the cooperation should be, and this represent a weak point. Still, there are such strong signals of the willingness of actors for cooperation that this undoubtedly is reinforcing network formation.

However, this scenario is highly subject to change, given that if the actual outcome for OWP implementation will be the Demo Rogaland concept, the network formation will then become quite degraded. The authorities could probably still have a chance of influencing the process of diffusing relevant learning, providing that they put strong incentives for inclusion of (the CEER) actors through a possible broadening of the concept for an additional network reinforcement.

5.5 The ambivalent role of the authorities on renewable energy

As Demo 2020 has struggled with internal network obstacles, the external network formation has neither gained any particular advantage by the ambiguous attitudes expressed by the authorities. For one thing, creation of two CEERs which have partly overlapping responsibilities and agendas, implies certain problems concerning focus. Nonetheless, the sectoral principle as discussed above, represent a superior obstacle. It seems that the overall problem regarding the ambiguous response from the government, ministries, and specific agencies, is that they are kept busy working on issues related to their core activity. The Ministry of Oil and Energy is by far mostly concerned with activities within the highly profitable petroleum sector; oil and gas (Fagerberg 2009a). Ministry of Trade and Industry (MTI) "is responsible for designating industrial policy with an eye to the future. This includes involvement in any policy area that affects value creation."[32] However, when the respective minister Trond Giske visited a newly opened wind farm in Scotland in May 2010 implemented by the Norwegian company Fred Olsen Renewables, he expressed that "it does not give any meaning to support a large scale development of renewable energy in Norway because of our high percentage of renewables already" [my translation] (Ellingsen 2010, p.75). He followed up by saying he was not sure whether "a home market is needed to ensure Norwegian actors' growth abroad" [my translation] (Bjartnes 2010), in which Fred Olsen asked for a more committing engagement. Giske replied when confronted with this: "Wind power in regions with energy deficit might be a solution, but this is in the minister of oil and energy's domain" [my translation] (ibid.). Although the creation of a home market is not the main target examined in this thesis, the ministry's flea from taking responsibility and throwing the ball to the other ministry, confirms the underlying problem, the barriers for cooperation created by the unfortunate sectoral division in Norwegian governance. This is confirmed by several actors in the industry. Anne-Grete Ellingsen, director of strategy and business development in SAE Vind[33], calls for better communication between these ministers, as well as the ministers of environment and local government and regional development (Ellingsen 2010). The fact that four ministries sit with their each own share of financial responsibility in this case (we could suggest five, including Ministry of Finance) and thus a hidden key to get the

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[32] http://www.regjeringen.no/en/dep/nhd.html?id=709

[33] SAE Vind is Statkraft's daughter company in charge of onshore wind development in Norway, created after a merger with Agder Energi, another big wind energy actor in Norway.

go-ahead for the Demo 2020 project, is symptomatic for the division of politics providing innovation and growth strategies in Norway.

This touches upon the sectoral principle's core dilemma. When each ministry has a fat pot of resources they may use the way they find to serve their goal in the best way, this mean they will prioritize their own domains, regardless of common visions in the neighbouring ministry (Fagerberg 2009b). This leads to major disadvantages when it comes to the national strategies for innovation performance. To overcome the barriers created by this (partly) acknowledged problem, the government tried to help this by creating a specific agency called Innovation Norway (IN), responsible for support and finance of innovation-increased activities in general. By an analysis of the ministries' communication with IN, these were more concerned with fulfilling their own specific goals rather than maximising their potential innovation performance (Aanstad, 2008, cited in Fagerberg 2009b).

A specifically created innovation agency should be concerned with core activities for raising innovation performance. As the primary sector in Norway is highly subsidized to support traditional district interests, two of IN's major responsibilities are support to agricultural and fishery related developments, supported by the two respective ministries. A strengthening and focus of future innovation strategies is thus highly needed. Fagerberg sums up the core idea of what such activities should be:

> Innovation concerns a stumbling in the darkness, a situation characterized by unreliability and high risk. An organization whose goal is to stimulate innovation should be tuned for this purpose. Innovation Norway's complex strategy structure hampers the possibilities for the organization to fulfil this role in a fair way [my translation] (ibid., p. 29).

The weaknesses identified in IN and its lack of cooperation, resembles similar shortcomings throughout the national innovation system. Enova, the agency specifically in charge of subsidies for energy projects, is another important example. It has been criticized for a lack of predictability, not treating support applications evenly, and operating without necessary transparency to its coordinator, MOE. Enova is subject to changed activities after the implementation of TGCs, so this is an acknowledged problem with prospects for improvement (TU 14/10).

Practical SNM-related regime implications

If we should take broad socio-technical transition towards sustainable economic development literally, it would then eventually imply that Norway would have to abandon oil and gas activities, at least in the domestic area. This is, in 2010, and within a reasonably short time frame, an impossible idea. The Norwegian government proposed in white paper no. 34 (2006-2007) that Norway should reduce CO2- emissions by 30% within 2020, based on numbers from 1990, and that the country will become carbon neutral within 2050. The paper suggests that to achieve this goal, significant reductions above 30%, alongside with buying CO2 quotas from other countries, will be needed. It does not mention whether Norway should phase out its petroleum activity. If we hold the EEA and the renewable directive apart from this discussion, it may be reasonable to assume that the oil and gas reservoirs may reach their extinction point before the authorities acknowledge that they might need to make changes to the socio-technical regime (BP 2010, p. 6),[34] at least counting the progress towards this goal as of today. Fagerberg (2009a) refer to this state as a *path-dependent lock-in situation*. This translates to Norway's deeply embedded activities within oil and gas production, institutionally enclosed in a complex governing system sharing massive financial power between the ministries of Oil & Energy and Finance. To find a key to un-lock this situation requires highly complex incentives and a legitimacy shift from petroleum-based energy to renewable (ibid.).

Disruptive changes in the socio-technical landscape

As indicated in the theoretical chapter, the cultural and natural environment is influenced by external changes, coincidences and occurrences. Climatic abnormalities can be among such. Draught or heavy rain can create shortfall or flooding of water. Electricity-wise, Norway is particularly vulnerable to years of sparse precipitation, and this is can create severe energy deficit. Norway also has, as experienced especially in the winter and spring of 2010, limited electrical grid capacity, reinforcing this problem. Particularly environmental disasters can, if the scale is large enough, create a specific shock that directly influences the socio-technical landscape, providing (usually) that the disaster is man-made. The Macondo well accident in the Gulf of Mexico in April 2010 represents such a specific shock. At the time of writing, the long term consequences of this environmental disaster are still unknown, although it is clear that they will be serious. The political consequences is also yet unknown, though political milieus have already stated clearly that this will put significantly higher pressure on drilling actors

[34] BP has calculated the known Norwegian oil resources to be used up within 8,3 years, counting by today's production rate. Gas resources may last for 20 years, according to the report.

globally, and specifically in Norway connected to the discussion of drilling outside the Lofoten archipelago (TU 32/10). This specific shock may open new opportunities for renewable energy in Norway, as presented in fig. 4, if environmentalist stakeholders are able to weaken the legitimacy for extracting fossil fuel in this area sufficiently enough.

It is reasonable then to assume that this specific shock may create disruptive change in the socio-technical regime. The result thus may strengthen the legitimacy for more environment-friendly energy sources, according to Geels & Schot (2007).

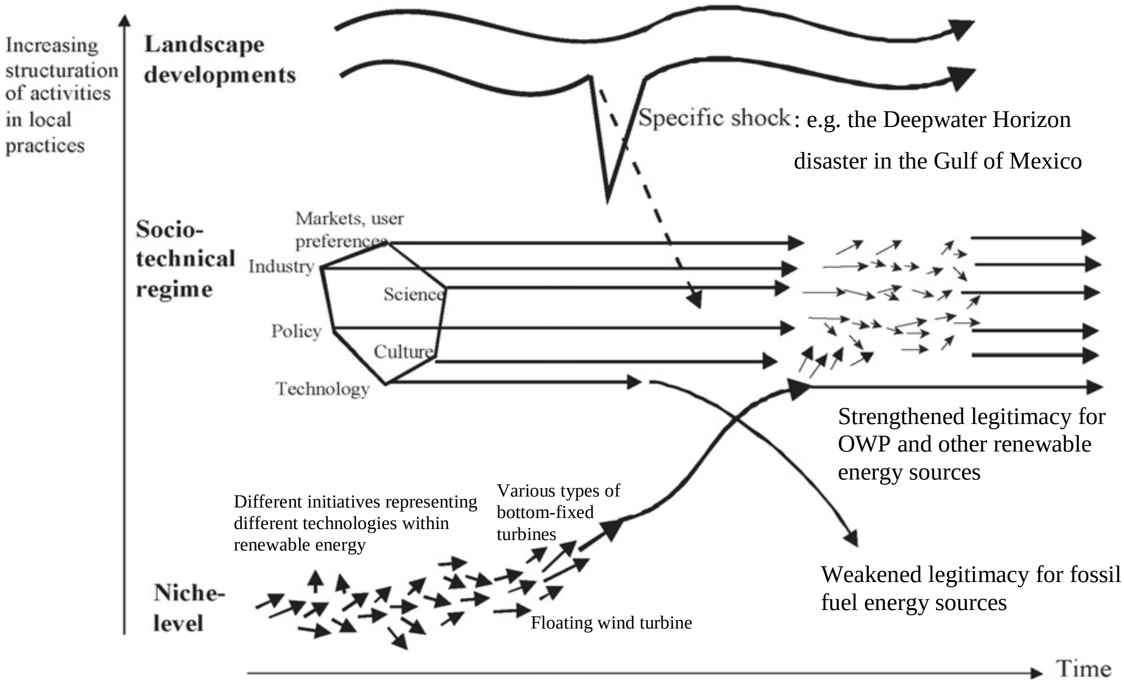

Fig. 4. Technological substitution pathway. Modified from a model by Geels & Schot (2007).

Still, this probably represents a landscape development which may take years or decades to influence fully. Almost half a year after this accident, it seems that the prevailing business model is again “business as usual”. Petroleum activities are highly profitable compared to most renewable activities. Thus, clearer and more efficient environment policies will be needed to overcome these institutional lock-in challenges.

Concluding remarks

To sum up, the role of the authorities and their practice represents a great ambivalence towards renewable energy goals. This can be defined as a reverse salient (Hughes 1987) in the network formation; that the public agencies act seemingly divided by with water-tight doors, each not taking enough account of the superseding agendas and strategies for R&D activities and business development. The petroleum based socio-technical regime is highly embedded in the national economy, making it extremely difficult to initiate any institutional change. Wealthy actors within this system guard their positions carefully, creating a landscape and regime context that provides major challenges to any regime change. An expected change might be enforced through the EEA agreement and the renewable directive, however.

5.5 Bridging the "valley of death" between R&D and market introduction

Scotland is known for providing a very efficient policy framework for renewable energy, and has implemented a certificate system securing both mature and immature technologies with good conditions. It is therefore no surprise that many Norwegian offshore related projects have emigrated to Scotland, whether being wind, wave or tidal power (TU 25/10). Using SNM as a tool for creating incentives for developing immature technologies has been outlined in the theory chapter. It is designed specifically to help overcome the "valley of death" between R&D and market introduction.

It seems to be a specific market for this in Norway, since the development of tradable green certificates (TGC) expected to be implemented in Norway from 2012 after a painstaking six years postponement, has proved to have serious shortcomings in this respect. This support scheme became subject to criticism when Bergek & Jacobsson

(2010) reviewed the results of the performance in Sweden so far, since its introduction in 2003. Their studies point to that the TGC support scheme should contribute to technical change and an aggressive development of immature renewable technologies, alongside with cost efficiency and an equitable distribution of costs and benefits. Their findings concluded that while maintaining profitability for actors supported by this scheme; this was incompatible with simultaneous provision of financial support for technological development of immature technologies. This is due to the fact that the TGC policy scheme is *technologically neutral* – it does not treat less developed and less profitable technologies in favour of mature and momentum-gained technologies like hydro power. The consequences are thus, that the mature hydro power industry become winners – and new renewable technologies losers (ibid.). Hopefully the conclusions from this report will be paid attention to, allowing for an additional policy scheme.

What Norwegian decision makers seemingly have problems to understand, is that quick-fix solutions for support of industries and traditional sectors, hampers the ability of acknowledging that support for sustainable technologies requires significant attention. This means a particularly organized environment and protected space, to cultivate mature market competitive solutions. Nonetheless, the many support schemes available through different support agencies makes it even more difficult to search for the right ones to use. Fortunately there are signs of a greater acknowledgement of this fragmentation among what is regarded as the "policy purgatory" (TU 29/10, p. 12) [my translation]. The Norwegian board of technology has pointed to the complete lack of any available summary of this, and they are thereby working on a project to provide a highly needed overview.

This board have also acknowledged that the valley of death represents the major obstacle as outlined above, and they are at the time of writing working on a forthcoming report suggesting the creation of a committee or fund, specifically in charge of support for promising technologies in need of heavy tailored funding (ibid.). The innovation scholar Bengt-Åke Lundvall (2002) has pointed to that the sectoral principle is a dilemma not only in Norway but also in Denmark, working specifically with issues concerning ministerial fragmentation. He refers to Finland where an "inter-ministerial council with direct responsibility for policy related to technology and innovation has been set up directly under the Prime Minister's chairmanship" (p. 52). Given the findings of the systemic shortcomings in this thesis, inter-ministerial planning and strategies would have been a very good idea to implement also in Norway. Fagerberg (2009b) as well, points to the need of a centrally governed agency addressed for large strategic projects, which may "exchange and draw conclusions of experiences, coordinate initiatives and take care of strategic functions. An example of such an actor is the Swedish 'Vinnova'" (p. 28) [my translation].

Thus, it appears that Norwegian decision makers will not need to travel any long distance to gain necessary learning of how to build up better innovation and technology strategies. Sweden and Finland are according to OECD some of the most successful nations when it comes to innovation policies (OECD 2008, cited in Fagerberg 2009b).

Concluding remarks

It is alarming that present applied renewable energy policies can have unfavourable shortcomings that lead to technology mismatch as outlined. Particularly when the consequences are under-stimulation of technologies with a high development potential – and a good economic potential in a highly competitive international market. A specific agency and inter-ministerial policies, taking particular care of these technologies – needs to be developed with a certain high emphasis on creating aid across the valley of death. Elaborating too much on the details of such a process would be beyond the scope of this thesis; nonetheless should the core of these recommendations be quite clear.

6 Conclusion

The analysis of Demo 2020 and its surrounding prospects has shown that the efforts from a (joint) Norwegian wind power industry to form a common plan for development of an offshore demonstration project, is a highly complex process. Several actors have shown willingness to plan and initiate such a test programme, but the coordination and cooperation of this plan indicates certain weaknesses. The actors have not shown clear signs of acknowledging that a distinct managerial role would help expectation coupling to merge into a strong solid vision, which again could make it easier to market the project to politicians and financially supporting decision makers. Nonetheless, the actors share a broad vision of expectations concerning the prospects of OWP in Norway and subsequent articulation processes. Certain milestones of Norwegian technological achievements, like Hywind and various foundation structures have already been made, reinforcing further expectation build-up. The industry clearly see advantages through Norway's already accumulated marine & offshore knowledge base, a good foundation to build further upon.

However, the external network formation processes show that the contextual premise, or the socio-technical regime, is not pulling in the same direction. Major challenges needs to be overcome, regarding institutional lock-in processes and an unfortunate sectoral division of political power and governance over necessary support policies. Nonetheless, slowly emerging changes in the socio-technical landscape provides increasing opportunities for renewable energies to influence the regime, in which wind power is considered one of the most important shareholders. Based on this, the findings in this thesis indicate that the Demo 2020 programme represents an important contribution for offshore wind power development by raising expectations and visions, by creating a deeper acknowledgement of the importance of network formation and possible articulation processes. These dimensions reinforce the niche formation process, and have set a focus to the structuration of local activities, which again facilitates niche influence and eventual embedding in the prevailing socio-technical regime. This may lead to successive technological developments, possibly reinforcing the process of enriching technological environments, stimulating further innovative activities and developments.

At the same time, several barriers represent challenges to the extent of implementation, given that OWP is very expensive and needs heavy financial support. This provides that the case is highly subject to change. If the response for public support may become insignificant, several wealthy private actors through the proposed project Demo Rogaland, may be able to pursue a smaller scale private initiative. This may not have the same qualities according to SNM theory, providing specifically shortcomings by poorer articulation processes and network formation. But after all, it is still a fairly good starting point for industrial Norwegian offshore wind power development, which most likely will continue to grow.

As to the question of increased supply of wind power based electricity production in Norway, the activities outlined will most likely diffuse expectations into a process of further development of wind power-generated production. This will particularly concern other plans for bottom-fixed OWP development discussed in the thesis, but it is not unlikely that learning processes also may be applicable for land-based wind power.

Practical implications

Application of Strategic Niche Management theory has shown that a thoroughly coordinated and planned development phase of such a plan is needed to gain a deeply rooted network of actors that share the same opinions on how to proceed, to obtain common shared expectations, actions and learning. If this preparation phase is pursued too fragmented, as so far seems to be the case, the project will suffer from inadequate political support and willingness to make a positive decision. If Demo Rogaland turns out to be the first project to be implemented, which may seem quite likely, it is important that a public strategy concerning systematic coordination of articulation processes will be followed up, to be continued for further (eventually phase 2) development of other demonstration programmes planned, regardless of actors or extent.

Further Research

The ESST master thesis is conducted within a relatively short time frame. This creates limitations to how deeply the theoretical implications applied on a case can be elaborated. Further research, containing more details on various themes discussed in this thesis would give readers a better chance to broadly understand the practical use that the SNM framework provides. Particularly PhD assignments would give a more fair chance to enhance in the SNM details, possibly creating better understanding for necessary policy development.

As the future of Norwegian wind power development is very difficult to predict, this provides a good climate for the need of further research that can contribute to enhance learning of more practical SNM implementation, providing guidance and steering the technological trajectories to be pursued.

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Appendix

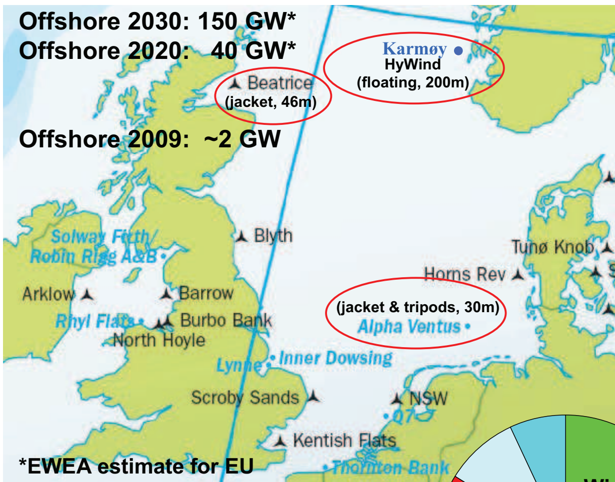
Abbreviations

ARENA	National program for long-term development of business clusters
Arena NOW	Arena Norwegian Offshore Wind (1st wind-oriented Arena cluster)
CEER	Centres for Environment-friendly Energy Research
CMR	Christian Michelsen Research AS
DEMO 2020	Demo 2020 – Norwegian OWP test and demonstration initiative
EEA	The European Economic Area
EL	Electricity Act
EU	The European Union
EWEA	The European Wind Energy Association
GW	Gigawatt
IFE	Institute for Energy Technology
ME	Ministry of the Environment
MOE	Ministry of Oil and Energy
MTI	Ministry of Trade and Industry
MW	Megawatt
NORCOWE	Norwegian Centre for Offshore Wind Energy
NORWEA	The Norwegian Wind Power Association
NOWITECH	Norwegian Research Centre for Offshore Wind Technology
NTNU	Norwegian University of Science and Technology
NVE	The Norwegian Water Resources and Energy Directorate
RCN	Research Council Norway
TGC	Tradable Green Certificates
TWh	Terra Watt hours
WMN	Windcluster Mid-Norway (2nd wind-oriented Arena cluster)

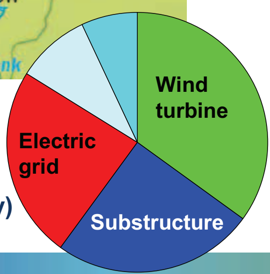
Demo 2020.
A test- and demonstration programme for Norway

Jan Onarheim
Vice Director NOWITECH
Project Director
NTNU
jan.onarheim@ntnu.no
www.nowitech.no

A huge international market

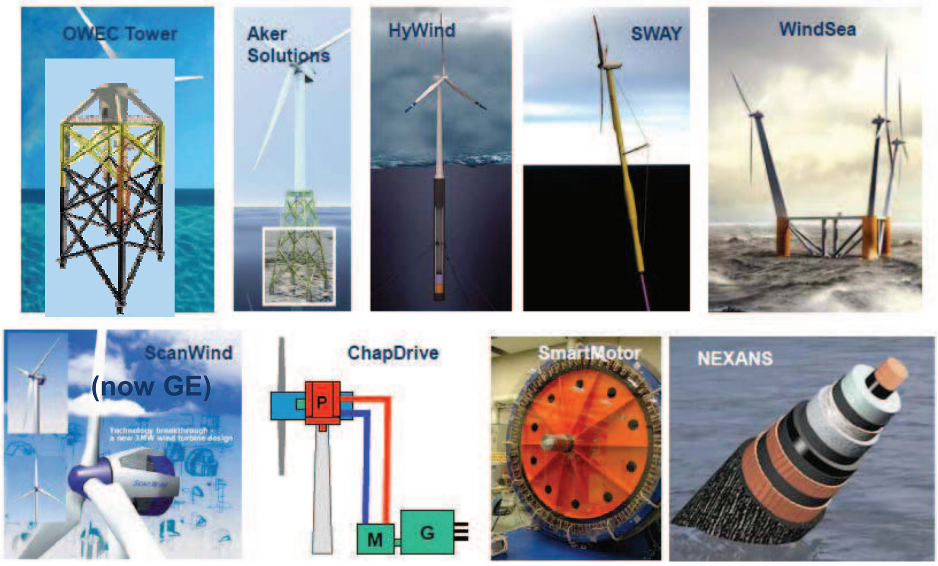


- Norwegian industry are taking part as wind farm developers and suppliers of goods and services
- This demonstrates ability to compete, BUT the question is how to secure future large supplies!

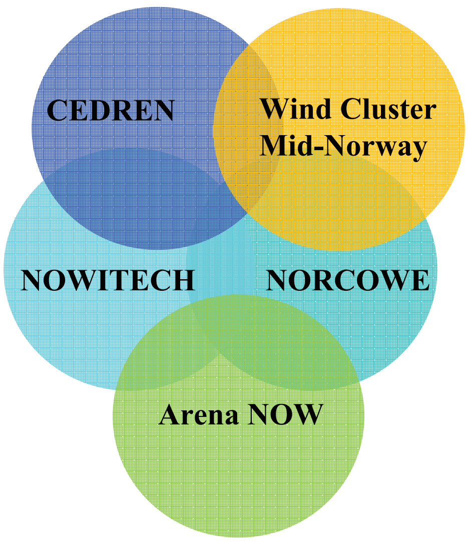


CAPEX distribution
offshore wind farm (DTI study)

Norway is developing offshore wind technology



A strong cluster on offshore wind



Test and demonstration program for offshore wind and ocean energy in Norway ”Demo2020”

arena Arena NOW (Norwegian Offshore Wind)
Arena Windcluster Mid-Norway

NOWITECH Norwegian Research Centre for Offshore Wind Technology

norcowe Norwegian Centre for Offshore Wind Energy

- The two offshore wind industry clusters Arena NOW and Arena Windcluster Mid-Norway together with the two research centres in offshore wind, NORCOWE and NOWITECH represents more than 100 industry companies, 5 universities and 4 research centres from Verdal in the Mid-Norway to Kristiansand in the South.
- The two industry clusters and the two offshore wind research centres have jointly proposed the establishing of a Norwegian test and demonstration program for offshore wind and ocean energy, ”Demo2020”.

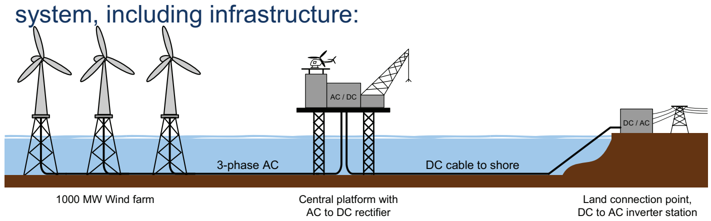
Goal – first phase of Demo2020

- Qualify Norwegian industry and suppliers to deliver to the offshore wind markets in Europe, especially to round 3 in UK and Germany.
  - Ensure that Norwegian suppliers can get track record and deliver to international offshore wind markets
  - Ensure testing of components before integrating in to a compete wind power system.
  - Qualifying of competitive and cost effective technology and services based on Norwegian offshore competence from oil and gas industry
  - Creating new products and services for a global market will establish new jobs in Norway.
  - Enable research centres to test components under real conditions as well as giving them access to real data for verifying models and theories.
  - Transfer research results to industrial activity.

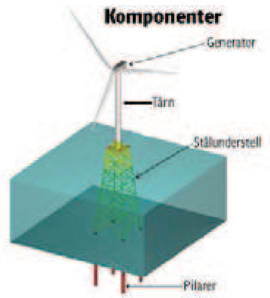
What is a demonstration program?

► An offshore wind demonstration program should support:

- a system part, i.e. full scale demonstration of the complete wind power system, including infrastructure:



- a component part, i.e. component tes installation methods, processes, fabrication methods etc.



Cost and timeframe for the first phase of Demo2020

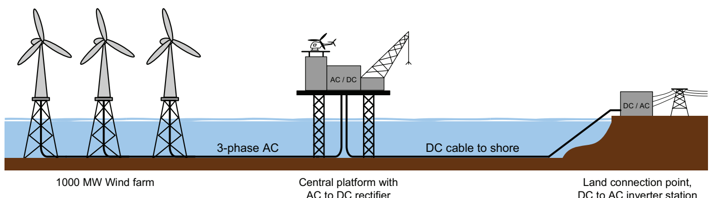
► The offshore wind development in Europe has already started. Procurement processes will start and contracts will be given to qualified suppliers from 2013.

► It is therefore important to start a test and demonstration program in 2011 in order for the suppliers to be qualified to deliver to the German and UK market.

► Demo2020 recommends a minimum program of 8 turbines/foundation (complete systems) within **2014**, of which the first one or two to be installed in 2012.

► A demonstration program with 8 complete wind turbine systems, infrastructure and a component part will have a total cost of 2,5-4 billion NOK.

► The governmental contribution should be large enough to reduce financial risk for the suppliers to contribute.



Demo Rogaland part of Demo 2020

- Statoil, GE and Lyse have signed a cooperation agreement to investigate the feasibility of a demonstration facility for offshore wind in Rogaland, Norway.
- The intention is to built two to four demonstration turbines and to test and qualify GEs 4 MW direct drive offshore turbine.
- The project will also give opportunities for other suppliers, such as foundation and cable supply and transport and installation services. These and other deliveries will be evaluated as part of the project development.
- As part of this cooperation agreement, Lyse has applied to NVE for concession to install wind turbines at three alternative locations near the coast of Rogaland. Concession for 2 off 4 MW turbines is applied both at Rennesøy, Kvitsøy and Karmøy.
- The companies will apply for funding from Enova as this project will depend on governmental funding to be realised.
- Investment decision is expected spring 2011.